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REPRINTS

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ANTIQUARIAN AND SCIENTIFIC SOCIETY OF THE CENTRAL PROVINCES.

The papers on the Geology of the Nagpore Province, by the Rev. Messrs. S. Hislop and Hunter, have been selected for the 2nd Number of the Series of Reprints, as they contain information of interest to all residents in the Central Provinces.

These papers were originally published in the Journal of the Geological Society of London, and have now been reprinted from the Geological Papers on Western India edited by H. J. Carter, Esq., F.R.S., late of the Bombay Medical Establishment.

H. RIVETT-CARNAC,
Honorary Secretary to the Antiquarian and
Scientific Society of the Central Provinces.

Camp, September 1867.

PAPERS

ON THE

GEOLOGY AND FOSSILS

OF THE NEIGHBOURHOOD OF

NAGPUR, CENTRAL INDIA.

BY

THE REV. MESSRS. S. HISLOP AND R. HUNTER.

Nagpore:

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ON THE GEOLOGY AND FOSSILS OF THE NEIGHBOURHOOD OF NAGPUR, CENTRAL INDIA.

By the Rev. Messrs. S. Hislop and R. Hunter.

PART I.

Geology of the District.

CONTENTS.

Physical Geography of the District.—The country to which the following paper refers is the western part of the recently acquired kingdom of Nágpur,* lying, with the southern corner of the Ságar and Narbaddá territories, between 78° 15′ and 80° 35′ east long., and 19° 35′ and 22° 40′ north lat. It is of a triangular shape, each side extending about 180 miles. Its northern side is formed by the table-land stretching from the Mahádowa hills on the north-west to the northern extremity of the Lánji hills on the north-east: the south-eastern side is constituted partly by the chain last mentioned, and

* With regard to the spelling and pronunciation of Hindu names of places, the authors have furnished the following remarks in one of their late letters to the Assistant Secretary:—

"Orthography in India is a very unsettled branch of learning. Those who first stereotyped in English characters the Hindu names of places were most unsuited for the work, and hence most unscientific is the system of spelling practised by the generality of our countrymen. We follow the Jonesian system, as it is adopted by such societies as the Royal Asiatic. By that every Hindu letter has an English representative, though that representative has more a Continental than an English sound attached to it. The vowels are *a, á,—i, í,—u, ú,—e,—ai,—o, au.* They are in pairs, short and long: *a* unaccented having the sound of *u* in *but*, *á* accented the sound of *a* in *have*; *u* the sound of itself in *full*, its long

partly by a line drawn from its southern base to the junction of the Wein Gangá and Wardhá, which latter river marks out nearly the whole of the south-western side. (See Map.) The limits, as thus defined, enclose an area corresponding with that surveyed by Lieutenants Norris and Weston in 1826, and amounting by their calculation to 24,000 square miles.

The City of Nágpur is situated very near the centre of this area. In the northern division, where the hills are both most numerous and most elevated, the direction of the ranges is east and west. In the southern, which contains a greater extent of level country, the course they take is generally north and south.

Chourágad, the highest summit of the Mahádewa hills and the loftiest point in our district, rises to an altitude of 4,200 feet above the sea; the usual height of the range, which, entering the Nágpur territory from Gáwilgad, passes by Dewagad towards Shiwani, is not above 2,000 feet, though in the east of the same chain, where it goes under the name of the Lánji hills, some of the peaks attain an elevation of 2,300 and 2,400 feet. At Nágpur the country has fallen to a level of 1,000 feet. On the west, however, it immediately rises by 200 or 300 feet in a succession of eminences, which run parallel to the Dewagad range, until they reach the basin of the Wardhá, when they suddenly sink in precipitous descents, as at Talogaum Ghát. Towards the east of the capital the plain extends almost without interruption to the banks of the Wein Gangá, where the general level is about 900 feet above the sea. Still further east, on crossing the river, we find the country preserving its former flatness, except that occasionally it is diversified by ranges of hills running north and south, of which that encircling the lake of Nawagaum is the most considerable. In the southern division of the territory there are few hills, if any, that rise above 2,000 feet; while the champaign tracts, which abound on both sides of the Wein Gangá and Wardhá, fall, ere these rivers have effected the junction of their united streams with the Godávari, to 800 hundred feet above the sea level.

It will thus be seen that our district presents a watershed from north to south. The most important rivers which flow through it are

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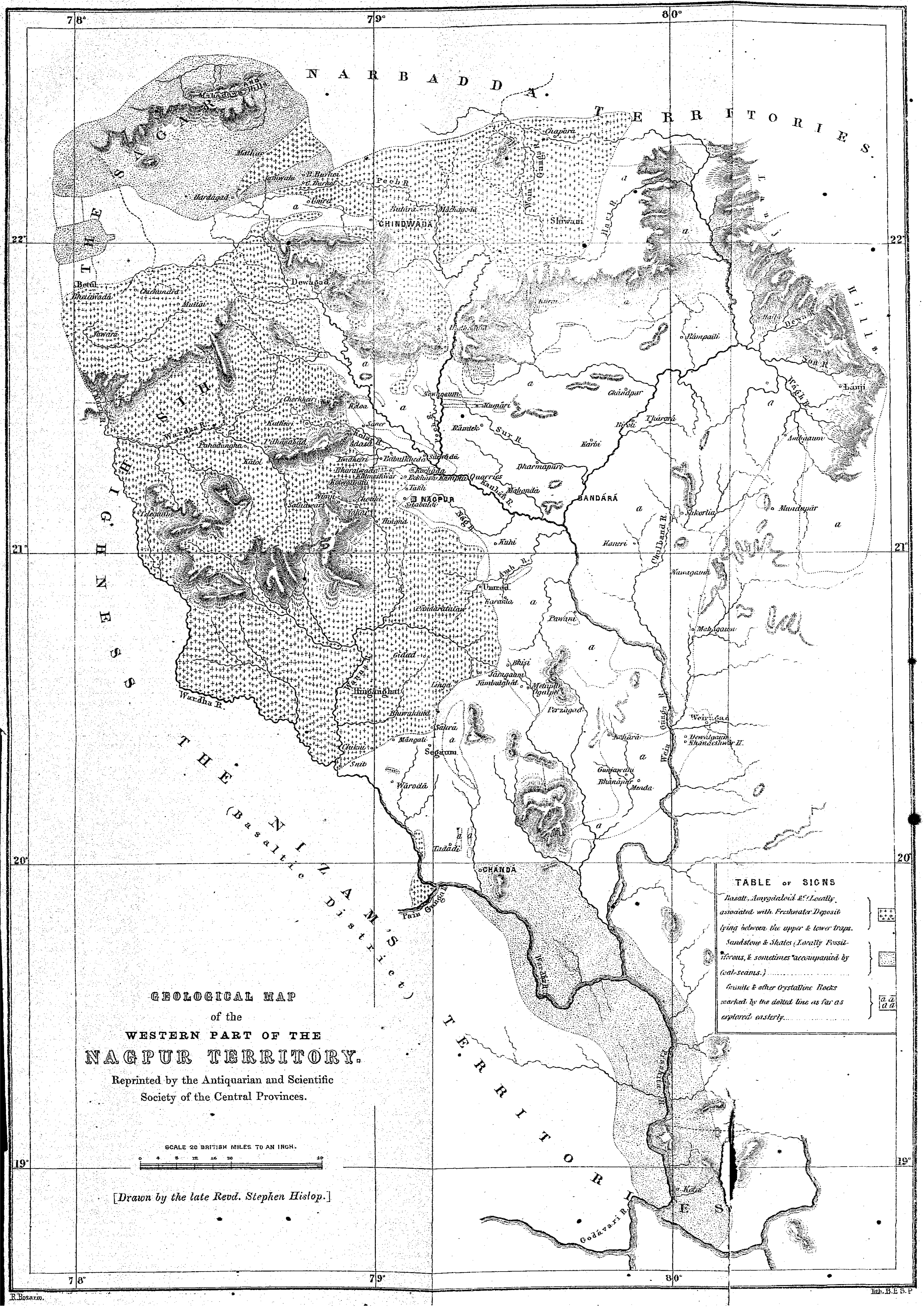
being just the same sound more dwelt on; *i* the sound of English *e*, made long or short as it has accent or no accent. There is only one consonant that may occasion difficulty, that is a *d* written in Italics. When so written or printed it is intended to have a sound somewhat like *r*. Thus we write Wein ágad, whereas it is commonly written Wyraghur. The *gh* for *g* is just a gross mistake, which destroys the etymology of the language to a person who does not know the original Hindu name. Silewádá, as written by us, is usually represented Sillewarra."



GEOLOGICAL MAP

of the

WESTERN PART OF THE

NAGPUR TERRITORY.

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[*Drawn by the late Revd. Stephen Hislop.*]


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the Kanhán from the Mahádewa Hills, which at Kámpti receives the Pech from the same upland tract, and the Kolár,—the Wardhá, which is joined by the Wanná from the hills west of Nágpur, and by the Pain Gangá from the Nizam's country,—and the Woin Gangá, the largest of all, which on its left bank is increased by the united streams of the Wágh, the Son, and the Dewa, and by the Chulband, and on the right by the Kanhán and Wardhá, after its confluence with the latter of which it takes the name of the Pranhíta, and ere long discharges its waters into the Godávari.

History of the Geological Observations of the District.—The geological structure of the territory, whose extent and natural features have been thus briefly described, has for some time engaged the attention of scientific men in India. Dr. Voysey and Captain (now Colonel) Jenkins were the first who examined it. From the result of their investigations, as published in the Bengal Asiatic Society's Transactions, Part I. for 1829, it would seem that they were unsuccessful in their search for fossils. The lamented Voysey, indeed, who was the first in India to find shells in a stratum enclosed in trap, thought he had discovered, on the journey hence to Calcutta, which terminated his distinguished career, bivalves in a bed of limestone near Ráyepur, within the Nágpur State, though on the east of our district;* but I have since ascertained† that the appearances which he regarded as organic are the consequence of the peculiar concretionary structure of the rock. The next observer within our field of investigation was Dr. Malcolmson, who in 1833, worthily following up Voysey's discoveries within the Nizam's dominions in 1819 and 1823, pointed out new localities for the formation in the same part of the country, and traced it into this kingdom to Chikni and Hinganghát. At the former of these places which is sixty miles south of the city of Nágpur, he met with *Unio Deccanensis*, *Physa Prinsevii*, *Paludina Deccanensis*, and *Melania quadrilineata*: at the latter, which is sixteen miles nearer the capital, he found an abundance of silicified wood. But, though he lived in this neighbourhood for some years, he does not appear to have been aware of the existence of similar organic remains here; and while, with Voysey and

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* Beng. As. Soc. Journ., vol. xiii., p. 856.

† The first person singular here refers to Mr. Hislop, by whom the memoir is for the most part written, with the exception of the description of the plants and insects of the tertiary deposits, which is from the pen of his fellow-labourer Mr. Hunter. For a previous notice of the "Geology of the Nágpur State," by the Rev. S. Hislop, see Journ. Bombay Asiat. Soc. No. 18, July 1853, p. 58 &c.—H. J. Carter.

Jenkins, he enlarged on the *mineralogy* of Sitábaldi Hill, like them he failed to advert to the two rocks which are its most interesting features —his own trap-imbedded stratum with Physas and Melanias towards the top, and an unfossiliferous member of the sandstone formation resting on gneiss at the bottom. In 1842 Lieutenant Munro, of H. M.'s 39th Regt., brought to light in the sandstone quarries near Kámpti, nine miles NE. of Nágpur, the impressions of ferns, which were forwarded to Malcolmson as having previously discovered the first vegetable remains in the sandstone of the Hydorabad country, by whom they were figured and described as resembling *Glossopteris Dancoides* of Royle.* As this species of fern is now understood to be a *Tæniopteris*, it seems likely that the comparison of the Kámpti specimens with it was incorrect, and that they belonged to a *Glossopteris* whose species, owing to the fragmentary state of the fronds, cannot be determined.

In 1845 I procured a few fossils of the same kind from the Kámpti sandstone, and two years subsquently my esteemed colleague the Rev. R. Hunter and myself fell in with them in the contemporaneous strata of Chándá, eighty miles south of Nágpur. None of these specimens, however, were preserved, nor was anything further done by us or by others to understand the palæontology of this part of India, until June 1851, when, walking with my fellow-labourer in the neighbourhood of our residence, two or three Physas, in a deposit enclosed in trap hill about a mile west of Sitábaldi, and two miles in the same direction from Nágpur, forced themselves on my notice. They were at once referred to the fossils which Voysey and Malcolmson had discovered in a similar situation, and the deposit in which they occur was identified with the freshwater formation that they had traced in several parts of the Nizam's territory, and at Chikni and Hinganghát, in this State. In a few days after, at the same spot, I found the first bone, and Mr. Hunter the first tooth; and, after a week or two, on Tákli Plain, about 2½ miles NW. of Nágpur, I met with the first fruit and Entomostracan. About the same time, from observing the traces of ancient vegetation on the soft clayey sandstone, used, in the absence of chalk, for whitening the writing boards in our Mission schools, I was led to make inquiries about the locality from which it was brought, which ended in the discovery of *Glossopteris* and *Phyllotheca* and some seeds or seed-vessels at Bhokárá, six miles north of Nágpur. Ere long we were joined by our friend Captain Wapshare, Judge Advocate of the Nágpur Subsidiary

* Bomb. Br. R. As. Journ., vol. i, p. 249.

Force, who added many valuable vegetable remains to our collection; and it is to his able and generous efforts that we owe, among other rare acquisitions, the first palm and the first mulberry-like fruits. From the red shale of Korhádi, seven miles north of Nágpur, I procured tracks of Annelids, and more recently, in combination with them, the footmarks of some reptile: and towards the end of the year, in company with Lieutenant Sankey of the Madras Engineers, I visited Silowádá, twelve miles north of Nágpur, where the sandstone yielded a repusion of rich and most beautiful specimens of *Glossopteris*, and whence have since been obtained a variety of exogenous stems, several species of *Phyllotheca*, and an interesting specimen, contributed by Mr. Hunter, of an allied genus, which by Lindley and Hutton is reckoned an *Equisetum*, and by Bunbury probably an *Asterophyllites*.* A Mission tour, undertaken about the same time, conducted my colleague and myself past the freshwater formation at Páhádsingha, forty miles WN W. of Nágpur, in which was detected an abundance of fish-scales dispersed through the stone. On our return, Mr. Hunter, among the seeds and fruits of Tákli, discovered the first specimen and the greater part of our fossil *Coleoptera;* while we received an accession to our collection of shells from Dr. J. Miller, then of the 10th Regt. M.N.I., who, while on an excursion with Dr. Fitzgerald, had found the freshwater formation at Butárá, near Machhagodá, eighty miles north of Nágpur, and also from Mr. Sankey, who had fallen in with it at Pilkápahád, twenty-five miles to the north-west. The latter-named officer, after discovering in the Kámpti quarries the first *Vertebraria*, a fine species of *Phyllotheca*, a long endogenous leaf, and an abundant kind of seed, all of which he liberally handed over to us, proceeded, along with Dr. Jerdon, the Indian ornithologist, in the direction of Butárá and the Mahádowa hills,† whence they returned with several new fossils belonging to our Eastern coal-formation, and excellent specimens of the shells previously collected by Dr. Miller, agreeing in general with those of this neighbourhood. In a portion of the Butárá rock which they kindly gave me, I was struck with the appearance of a diminutive creature, which proved to be a second genus of the *Entomostraca*. Ere the first anniversary of the discovery of our earliest *Physa* had come round, several other localities had been ascertained for both the freshwater and sandstone fossils, and observations had been made on the remains of quadrupeds and shells imbedded in com-

* Quart. Journ. Geol. Soc., vol. vii., p. 189.
† Ibid., vol. x., p. 55.

paratively recent deposits. Since that, on our annual Mission tours, we have become acquainted with a productive site for sandstone organisms at Mángali, sixty miles south of Nágpur, which has afforded a few unusual vegetable remains, a species of *Estheria*, scales and jaws of fish, and the entire head of a saurian; we have passed through districts abounding in laterite and iron ore, and have increased our knowledge of the geological structure of the country generally.

General Geology of the District.—From the rapid survey which we have taken in the preceding historical introduction of the fossils that have been brought to light within our area, it is obvious that its palæontology, contrary to the common idea of Indian formations, is both varied and important; but even in a lithological point of view there are few tracts of equal extent that are worthy of more attention; and of all the portions of that interesting area there is none for interest that can be compared with the vicinity of Nágpur,—its centre at once political, historical, and geological. We have only to take a few steps from our house and we reach the summit of Sitábaldi Hill, the scene of as heroic a conflict as ever our countrymen gained in the East. The spot on which we stand consists of nodular trap.* At the distance of a few yards from our feet, just under the brow of the hill, is a narrow stripe of green or yellow calcareous indurated clay, which on close inspection is found to contain a number of decaying casts of freshwater shells. Under this we perceive a bluish-green friable rock, which hardens first into a tough amygdaloid, and then, a little above the level of the plain, down to which it is scarped by the quarrymen, into a compact greenstone. Cropping out from under the foot of the hill may be seen a bed of soft variegated sandstone, and then, according as we look east or west, the prevailing rock covering the plain beyond is either gneiss or trap.

But let us extend the prospect to the horizon. As we stand with our faces to the north, the first glance that we cast on the distant hills shows that there is a marked difference among them. Behind us, on our left, and in front, we follow a long sweep of flattened summits, with here and there a valley to break the uniformity; but no sooner do we look towards the right than we descry a series of round-topped hills rising

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* Plate VI., fig. 2.—*Section through Sitábaldi Hill.*—*a*, Overlying nodular trap; *b*, Freshwater tertiary; *c*, Underlying trap, vesicular for some feet under the freshwater deposit, then compact, but nodular at the sides; *d*, Highest member of the sandstone series, which most probably underlies the amygdaloid throughout; *e*, Gneiss, into which much of the sandstone has been transformed; *f*, Pegmatite.

Fig 1

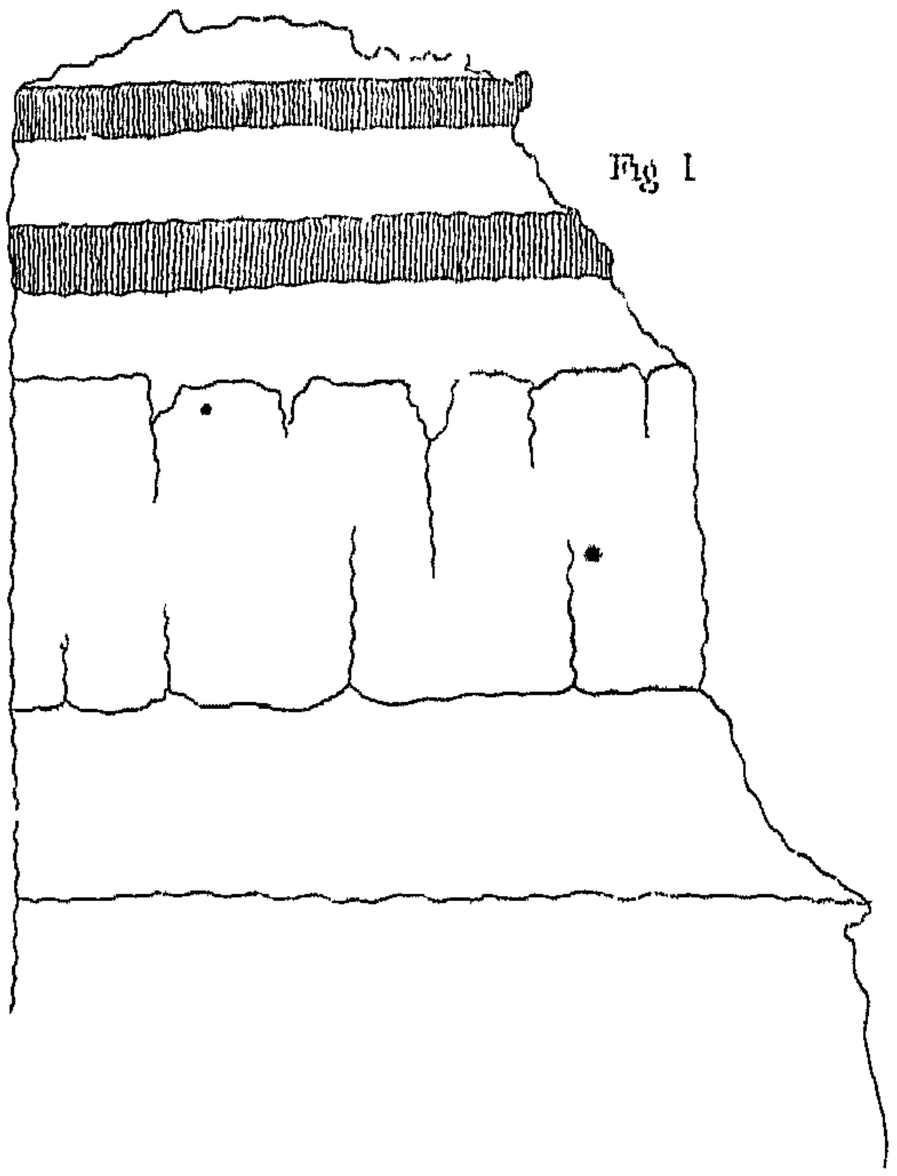


Fig 2 Section through Sitábáldi Hill, P

Fig 3

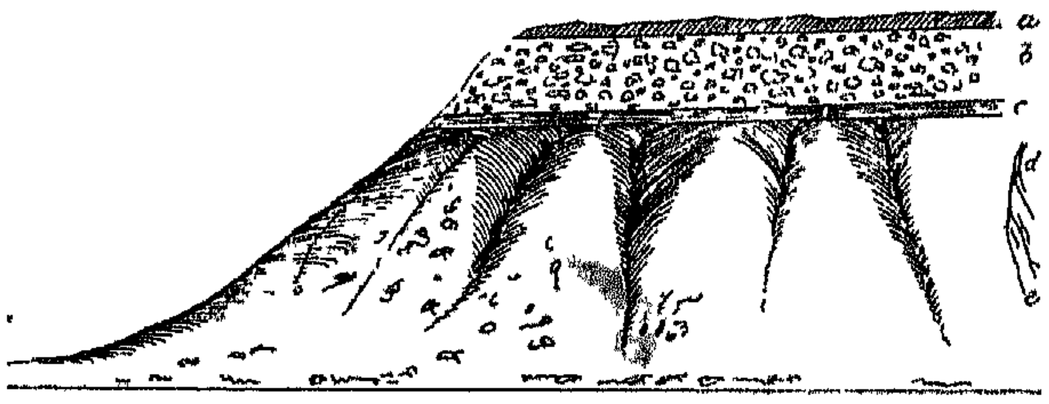
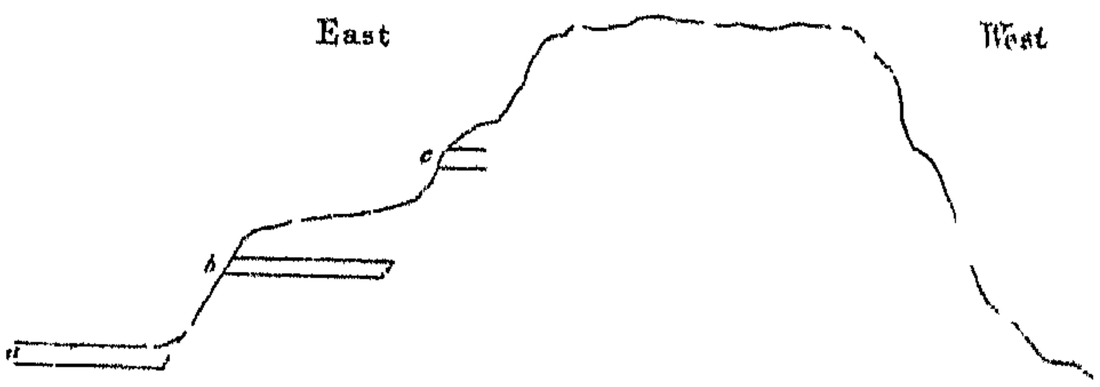


Fig 4



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up at intervals in massive strength. These flattened summits are the tops of trap hills, which stretch, in the form we see, from our present position to the coast of the Arabian Sea; and these massive eminences are granitic hills which rise up in the manner that meets our eye, at various distances from each other, from the place where we stand to the Bay of Bengal. The intermediate hills and plains, which in front fill up the foreground, are formed of the dolomite and shale of Korhádi, and the sandstone of the basins of the Kanhán and Kolár.

From our elevated station we are thus enable to command a prospect of twenty miles in every direction, and the formations that we can trace within that range make up an exact miniature of the geology of our whole area. Nay, were we to go down the hill and walk around its base, in the descent and circuit, which might all be accomplished in twenty minutes, we should meet with almost every rock that is to be found between Bombay and Katták.

The geology of our area must at one time have been extremely simple. Its principal feature was then sandstone, associated with shale and limestone. But now other two formations are discovered on the arena, and these seem on the surface as if they had been two huge icebergs which approached each other in frightful collision, crushing the sandstone between them, and allowing the fragments to slide out at either end, and scattering them here over their own bulk. Or, to speak in language more precise, the sandstone formation, which once occupied the whole space that we have chosen for description, is now covered up by trap on the west, and broken up by granite on the east, leaving only a small diagonal stripe running through the centre, which, after being interrupted at the north-west and south-east, increases in these directions to a broad expanse, while a few detached portions formerly continuous with it appear in the body of the trap and granite. It is the juxtaposition of trap, sandstone, and granite in this neighbourhood which invests the geology of Nágpur with special importance, and which, when investigated by competent observers, may shed a flood of light some future day upon Indian geology in general.

Trap Rocks of the District.—The greater part of the trap within our area lies in the west in the shape of a parallelogram, one of whose corners has been encroached on by a projecting portion of Berar and the Betul district of the Ságar and Narbaddá territories. Its greatest length is 120 miles, and its breadth is from 50 to 60. Its south-western side, on which the irregularity of figure is found, and by which it joins

on to the great sheet of basalt in the Dakhan, is formed by the Wardhá. Its south-eastern side, commencing from Suit, on that river, crosses the road from Nágpur to Chándá, on the south of Chikni, and, passing by the north of the Mángali fossiliferous quarry, extends to Sákrá and Bhiwákund, after which it coincides very nearly with the political division between the Súbás (provinces) of Nágpur and Chándá, which stretches by Lingá, Jámgaum, and A'lasur hills to the north-west of Bhísi. Here begins its north-east side, which skirts the small patches of sandstone on the west of Umred and Kuhi, and running close by the city of Nágpur meets with an eruption of granite, and then touches the sandstone basin of the Kanhán and Kolár, after which it again encounters plutonic rocks on its passage up the right bank of theKanhán to Dewagad. At this ancient Gond fortress the upland tract of Multái, which constitutes the north-west side, joins that last described, and completes the parallelogram.

In addition to this, the main body of trap within our area, and connected with it, there is a smaller development of the same formation in the north. Stretching south and east from Dewagad, it fills up the space between the Kanhán and the Pench, and, sweeping westward round the granite at Chindwádá, and eastward by way of the summit of Kurai Ghát to Shiwani and Chapárá, it merges, along with the Mathur range of hills, in the basaltic district that extends to the Narbaddá at Jabbalpur.

The above is, I believe, all the overlying trap within our area, with the exception of one or two isolated portions south-east from Suit, near Waroda.

Granitic and Schistose Rocks.—The plutonic and metamorphic formation the extent of which I shall now briefly indicate lies chiefly in the eastern portion of our area. It is intersected by the Wein Gangá for the greater part of its course. The tract on the left bank of the river I have had little opportunity of exploring; but, from the cursory examination I have given it, I have reason to believe that there is a large development of granite and its allied rocks, including an extensive outburst of porphyry, which coincides nearly with the upper portion of the course of the Wágh river. This eruption exhibits crystals of quartz, and of white (occasionally red) felspar imbedded in a dark paste of the same ingredients. On the right bank of the Wein Gangá, in the districts near its junction with the Wardhá, the extent of the formation is not so great. It is observed principally in the channel of the Wein Gangá, though it may also be traced around the bases of the sandstone chains of hills

which it has been the means of upheaving. In both the districts under consideration the general strike of the strata is N. and S., corresponding with the direction of the streams and mountain ranges, and in that last mentioned the dip is for the most part to the west. But it is on the north that the greatest development of granite and crystalline schists occurs. There we may perceive these rocks rising to the surface (though it would be hazardous to conclude that there are not others of a different character in the hollows covered up by the deep soil) from Nágpur northeastward to the Lánji hills,—a distance equal to the length of our trappean parallelogram, and with a breadth in proportion. This second parallelogram is applied perpendicularly, but unequally, to that previously described. Near the line of contact, *i.e.*, in the district near Nágpur, the gneiss and other metamorphic rocks, like the hills and tributaries of the Wein Gangá which run through it, have uniformly an east and west direction, with veins of the massive rock penetrating them at right angles to the strike.

This is the case with the crystalline formation north of the Kámpti quarries, which has communicated to the sandstone strata there and at Silewádá a southerly dip. As the granitic eruption, however, is traced up the basin of the Kanhán, it is seen to bend round a little, and to give a westerly inclination to the sandstone at Bábulkheda, Tondakheiri, and Adassá. From the last-mentioned place it proceeds northwards past Sáner and Kelod, in a narrow stripe on both sides of the Kanhán up to Dewagad. Beyond this we find it rising up around Chindwárá, and running west to Betul. But returning to the neighbourhood of Nágpur we discover, parallel to the great body of the granitic formation on the north of Kámpti, a range of quartz hills running in the line of the strata westward from Wáregaum to Guntárá. The plutonic force, which has tilted up these, has greatly disturbed the limestone rocks at Korhádi, and given to the sandstone at Bhokárá, on the south of the Kolár, the same dip as we observe at Silewádá and Kámpti on the north of that river.

Sandstone.—But let us now refer to the sandstone formation, which I have said exists in the central parts of our area, though only the wreck of what it once was. Its upper member, reduced in thickness by metamorphic agency, may be observed horizontally entering the trap hill of Sitábaldi on the east side, and again emerging on the west. It is then wholly displaced by gneiss and granite towards the Nág river, after which it again becomes the surface rock for a short distance to the west, until it is a second time overlaid by trap. It remains thus concealed for sixteen miles, when it is seen on the north-west of Yahár

at Nimji, whence it extends to Sátnawari on the south-west and Kotwálbadi on the north-west. At those villages it is a third time covered up by trap, nor does it in that direction rise again to the surface within our area, or indeed, I believe, anywhere beyond it. The division of this formation, which proceeds to the north of Nágpur, occupies a part of the basins of the Kanhán and Kolár from Kámpti on the south-east to Kelod on the north-west, being about thirty miles long and twelve broad. Its north-eastern border touches the great granitic tract which stretches from Nágpur to the Lánji hills, while its south-western boundary is constituted by the trap, surrounded by which three of its detached portions are found at Kutkheiri, Chorkheiri, and Chicholi, near the source of the Kolár. Were we to follow the direction of these outliers, they would lead us to the sandstone hills beyond our area that skirt the southern side of the trap chain of Gáwilgad, north of Elichpur. But if we suppose the sandstone continued north-west in the line of the Kanhán's course, we arrive, after crossing some miles of trap and granite, at the beds of carbonaceous and clayey shales, which, running under the trap range of Mathur, appear on the north side, and form the base of the lofty development of sandstone at the Maháděwas. The largest body of this formation, however, lies to the S. in the basin of the Wardhá and Pranhítá, extending, from the termination of the basaltic effusion at Jáungaum Hill and Suit south-east towards Badráchellam in the Godávari, with only a few outliers of trap, as before mentioned, near Waroda, some slight intrusions of plutonic rocks at Segaum and the west of Chándá, and a prolongation of the granitic series of the Wein Gangá basin, which runs south by Dúbá as far as Dowalmari, and reappears from under sandstone at the mouth of the Indrawati in connection with an extensive outcrop of schistose strata terminating at Tekalágudam.

A very marked feature in the geology of the country between the Iri and the Wein Gangá is the occurrence of ranges of sandstone hills running for the most part north and south, corresponding in general direction with ranges of the same formation in the district of Kotá, described by Dr. Bell.* These hills, where they have fallen under my observation, rise from plains of plutonic rocks, by which the strata have been indurated and elevated, though still retaining the horizontal position. Such is the flat-topped chain which stretches on the east of Segaum, and that which terminates in the castle-like bluff of Porzágad.

* Quar. Journ. Geol. Soc, vol. viii., p. 230.

On either side of the Wein Gangá we meet with some isolated remnants of the sandstone formation. One of these, but very limited in its dimensions, lies on the banks of the Selári, a small stream which joins the Wein Gangá near the town of Pawani. Another, further down the river, extends for some distance, first on the right bank and then on the left. In the district on the east of the Wein Gangá a little sandstone proper is met with, in patches among the hills on the west bank of the Gárwi and Wágh rivers, reaching from Mahágaum as far north as Ambgaum.

Laterite &c.—In various parts of our area we meet with beds of laterite, covering the rocks already described. I have not found it on the west of Nágpur; but it is seen abundantly within the trap district at Ságar, N. of Dudhgaum, and at Pándarataláw, SW. of Umred. At Karanlá, E. of the same town, it overlies plutonic rocks, and from Pawani, on the Wein Gangá, it stretches in a broad belt, sometimes over sandstone and at other times over gneiss and granite, towards Weirágad. South and west of this throughout all the province of Chándá it seems more or less. I have already mentioned the fact of its resting on dolomite at Ambájiri. At Máhonda, on the Kanhán, straight east from Nágpur,—at Dharmapuri and Karbi, in the basin of the Súr River, which flows from Rámtek into the Wein Gangá,—and again in the neighbourhood of Chándpur, further up the Wein Gangá, the same formation is presented to view. But it is on the east bank of the river that its most extensive development is witnessed. Crossing the Rayepur road at several places, it unites on the north of it to form extensive tracts in the district of Lánji, and all around Hattá and Kámtá.

The superficial deposits that are superior to laterite are either red or black. The former is found in general where plutonic rocks, sandstone, or laterite prevail, though instances are not rare of the latter being met with in such situations. The "regur," or black soil, occurs almost universally where trap abounds.

Description of the Strata.—Having thus given some account of the extent of the formations within our area, as they appear on the surface, I shall now endeavour to point out in a descending order their thickness, nature, contents, fossil or mineral as the case may be, and age.

Superficial Formations.

1. *Black Soil or Regur.*—The regur* is of no great depth in this

* In a Memoir on the "Geology of the Nágpur State" submitted by me to the Bombay Br. R. Asiatic Society in March 1853, and published in their Journal for July of that year, I made some remarks on the origin of the regur. Dissenting both from Voysey's theory of its arising from the decomposition of trap, and Newbold's view of its deposition in the sea

district, seldom if ever exceeding 20 feet. In some places, as at Tákli village, it is soon to overlie a stratum of brown tenacious clay which, like itself, is much mixed with "Kunker." I have not succeeded in finding any organic remains in the regur, except bones of oxen and sheep of very doubtful antiquity.

2. *Red Soil.*—The red soil in our area is of greater depth than the black, frequently displaying a section of 50 feet. Like it, it seems to rest on a brown calcareous clay, at the bottom of which there is in general a layer of conglomerate. In river-basins it alternates with layers of loose sand and gravel, often imbedding existing fluviatile shells of the genera *Melania*, *Corbicula*, and *Unio*. In the district west of Nágpur the rivers often expose a bed of sand and gravel cemented by a small quantity of lime, and in its consolidated state furnishing blocks of sandstone or conglomerate two or three feet thick. This stratum for the most part is unfossiliferous, but near the Kolár, about ten miles north of Nágpur, there occurs in it an abundance of *Paludina*, *Melania*, and *Corbicula*, which, though belonging to existing species, from the nature of the matrix have been much altered since the period of their deposition. Of some the cavities are simply filled with siliceous and calcareous matter, but in the greater number of instances the shell has been completely absorbed, and employed as a cement in aggregating the particles of the rock. A similar deposit is seen at Nágalwádí, near Ellichpur, to the west of our area; but there, in addition to the fossils just mentioned, it includes *Limnæus*, *Planorbis*, and *Unio*. On the banks of the Sarpan river, near Tondákhoiri, fourteen miles NW. of Nágpur,

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I suggested, from the analogy of the *Tchermoisem*, the probability of its being a subaërial formation that had taken place in marshy situations, where, of course, vegetation would be abundant. As this suggestion has been misunderstood, I may here take occasion to explain it. I never supposed that there was no clay on the surface while the regur was being formed. There is clay in the Russian soil, with which it was compared. What I intended to say was, that while there was a basis of both silica and alumina (the *débris* not of trap exclusively, but of any rocks in the neighbourhood capable of yielding them), this basis existed in a locality characterised by the excess of its moisture and the rankness of its vegetation, to which two circumstances, and not to the nature of the original *débris*, was due the colour of this celebrated soil. That these causes are adequate to the effect will, I think, be admitted. Stagnant water, as may be seen in cesspools, always communicates a blackness to its sediment; and the grass and other plants that would flourish in the circumstances which we have supposed would tend materially to the same result. To account for appearances of stratification in the regur, it may suffice to remark that I take for granted that rains, and all the other influences which rearrange and commingle the soil of the Dakhan at present, were at work in former times. The depth of the cotton soil is somewhat overstated in the text. Ten feet is its greatest thickness even in Berar, where we may look for its most typical features. There also it is underlain by brown tenacious clay that would retain the moisture on the surface

there is an accumulation of the freshwater shells previously enumerated, with a considerable intermixture of a species of *Bithinia*, and a few specimens of land shells—*Helix* and *Bulimus*. Mingled with these remains of *Mollusca* there was a quantity of jaws, vertebræ, and other portions of *Mammalia*, which were not much petrified; but, I regret to say, they were accidentally destroyed before they could be examined.* In the bank of the Kanhán at Kámpti, about 45 feet under the general surface, I found the shoulder-bone of some mammifer, much increased in weight from the process of petrifaction. Bones in the same state have been discovered lying above ground between Nágpur and Kámpti, which must have been washed out of the kunkeraceous red soil.

Judging from the relation of the regur and red soil to the brown clay, I am inclined to regard these two formations as contemporaneous; and, from the evidence of the fossils contained in the latter, I would class both as Post Pliocene.

II. The *Brown Clay*, on which I have said both the red and black superficial deposits rest, averages, together with its underlying *conglomerate*, a depth of 20 feet. The clay is not known to be fossiliferous, but in Tákli Plain there were found, in the conglomerate, apparently the tusks of a large mammal, which had been completely converted into stone, but they were so much affected by the weather as to fall to pieces on being removed. The formation containing them I suppose should be assigned to the Newer Pliocene, and will rank with similar deposits at Jabbalpur and elsewhere.

III. *Laterite*.—This formation seldom exceeds 10 feet in depth anywhere in our area. No fossils have yet been discovered in it here, but diamond mines have been opened in it east of Nágpur. Malcolmson,* and after him Newbold, inferred the identity of the sandstone of Central with that of Southern India from the existence of diamonds at Weirágad, a town about eighty miles SE. of the capital. The inference, however, is drawn from erroneous premises, which would have been corrected had these authors personally visited the spot. At Weirágad there is no sandstone near the diamond mines; the only rock in the vicinity is quartzose and metamorphic. It has been too much

* Some fragmentary bones, from the banks of the Sarpan, imbedded in a sandy earth, and associated with numbers of *Melania*, *Paludina*, and *Unio*, form part of the series of organic remains forwarded by Messrs. Hislop and Hunter. The bones, having been kindly examined by Professor Owen, prove to have belonged to Ruminants of two sizes,— such as a buffalo and a small antelope —Ed. Quar. Geol. Soc. Lond.

* Bomb. Br. R. As. Soc. Jour., vol. i, p. 250.

taken for granted, in my opinion, that the diamond conglomerate of Southern India is connected with the sandstone, within tracts of which it is sometimes found; and hence the arenaceous strata of the peninsula have actually come to be designated by the name of diamond sandstone. Now although the diamond conglomerate has been found reposing on sandstone beds, yet there is no instance, that I am aware of, of the diamond having been extracted from any one of them, nor are there any data to prove that the conglomerate derived most of its materials from that source. On the contrary, Heyne* has shown that the pebbles at Kondápetta and Ovalampallia, near Kaddápá, are chiefly of chert and jasper, basalt, quarter, hornblende, and felspar. The first two have evidently been derived from the limestone of the neighbourhood, and the rest from igneous rocks. And these pebbles are not contained in a paste of sand, but, according to Heyne, of clay.† It is true the diamond conglomerate may in one place overlie sandstone; but in another place, as at Kondápetta, it may rest upon limestone, while in a third, as at Bejwádá, near Másulipatam, according to the statement of Captain Newbold, it may be found immediately above gneiss ‡ In short, I am inclined to concur in the verdict long ago pronounced by that experienced Indian observer Dr. Heyne, when he remarked, "All the diamond mines which I have seen can be considered as nothing else than alluvial soil" (superficial deposit). But if the matrix of the diamond be a surface deposit overlying several rocks, I can perceive no propriety in attaching its name to one of these more than another. The matrix at Woirágal is a lateritic grit, and it is worthy of notice that wherever the precious gem is sought for, whether in India or Brazil, there for the most part oxide of iron is diffused.

Having myself met with no fossil in this formation, I have nothing to offer by way of determining its precise age, but would content myself with remarking that it must be posterior to the overlying trap, on which it is found occasionally, though in our district very rarely, to rest.

IV., V., & VI. *Trap and its enclosed Sedimentary Formation.*—The next rock to laterite in the order of downward succession is the overlying trap, with which, however, for the sake of perspicuity, it will be necessary to combine the freshwater formation previously alluded to, and the underlying trap.

Trap, it was before stated, is the prevailing formation in the west of our area; but when that assertion was made it was understood that this

* Tracts on India, p. 97. † Ibid, pp. 96 and 105.

‡ R. As. Soc. Journ, vol. viii, p. 245.

volcanic rock is of two kinds,—one overlying and the other underlying; and that between these two, and therefore seldom exposed to view, there is for the most part found an aqueous deposit. All three generally occur together. The exceptions are met with in the plains on the outskirts of the trap formation, where we not unfrequently observe the usually enclosed stratum resting immediately on sandstone, without the presence of either the upper or lower basalt. In some of those instances it is probable that the overlying rock has been removed, and cases occur of its remaining where no underlying trap has ever existed. On the other hand, there are examples in similar border localities of a single sheet of trap extending over sandstone without being associated with a second sedimentary formation or volcanic effusion.

Though the three formations are generally connected with each other, yet it is chiefly the upper one, viz., the overlying trap, that meets the eye over the face of the country. Leaving out of consideration the very few examples of denudation which have uncovered the freshwater deposit in the plains, and the equally rare instances of eruption which have there upheaved it on its edge, it is on the escarpments of the table-lands that we may be said to gain our whole knowledge of this department of Nágpur geology. In commencing our ascent of those steep hills our attention is attracted by a number of blocks near the foot, which are easily distinguished from the masses of basalt among which they have fallen from all above. As we make our way up over the hard, dark, vesicular rock, the blocks increase in number, until we come to a friable greyish or bluish-green zone. We must now move slowly and look narrowly, for a few yards of upward progress may conduct us from the soft amygdaloid, where fragments are thickly strewed, to a nodular basalt, where not a trace of them is to be seen. Occasionally the freshwater formation is so thin that a very little earth or herbage may suffice to hide it from our sight. But generally the water from the brow of the hill in the monsoon collects into little rills just at the place where it leaves the nodular trap, and having now gathered enough of strength to make an impression on intervening barriers, it proceeds to plough up the soft deposit, and the still softer subjacent amygdaloid, leaving an interval between each streamlet, like a talus resting on the harder vesicular rock below (*see* fig. 3).* The thickness of the overlying trap on Sitábaldi Hill and the tabulated summits in its immediate

* Pl. vi., fig. 3.—*Sectional View of one of the Trap Hills near Nágpur.*—*a*, Surface soil; *b*, Nodular trap (15 to 20 feet thick); *c*, Freshwater deposit; *d*, Soft amygdaloid; *e*, Hard amygdaloid.

vicinity is from 15 to 20 feet, which agrees very exactly with the thickness assigned to it by Dr. Voysey at Jillan. On the Western Ghâts, however, according to Colonel Sykes, a stratum of earthy jasper, which is just our freshwater deposit, was found near Junar under a thickness of from 300 to 600 feet of basalt.* But it not unfrequently happens that in leaving the plain and climbing up a trappean hill we may come upon the freshwater deposit at three distinct elevations. There is, first, the stratum which underlies the nodular trap generally throughout the plain, and which may be seen sometimes laid bare at the commencement of the ascent; then, after passing over hard and soft amygdaloid, we come to another bed, overlaid by nodular trap; on gaining the top of this we reach a terrace, which conducts us to another ascent, where we find, ere mounting to the summit, a repetition of amygdaloid, sedimentary rock, and globular basalt. An example of this occurs at the hill of Gidad, forty miles S. from Nágpur, the top of which has been appropriated by the disciples of a Musalmán saint named Shek Farid, to a mendicant establishment, which is supported by the donations of Hindus and Muhammadans alike, from all parts of the Nágpur territory. *See* the accompanying section of the hill from east to west (fig. 4),† where *a* is the deposit in the plain, white; *b*, the stratum of a red colour under the terrace; and *c*, a repetition of it higher up, brownish green. Whether there was a fourth stratum above *c*, the quantity of brushwood, and want of time, prevented me from observing. That all these strata are one and the same, though they differ in hue, I have no doubt. When we become acquainted with the changeablenes of this deposit within a space of a few yards, its different phases on the eastern declivity of Gidad Hill occasion no difficulty. Near Kátol, forty miles NW. from Nágpur, a similar appearance is presented. There a thick stratum of red clay lies at the foot of the hill, and we see its tendency to slope upwards and lean against the ascent; but we leave it behind, and come upon the amygdaloid, which emerges from under it. The amygdaloid is overlaid by a bed of red clay, which is surmounted by nodular trap constituting a terrace. Above this, before we reach the summit, we meet with a succession of amygdaloid, red clay, and nodular trap

* Trans. Geol. Soc., 2nd Ser., vol. iv., p. 419 [and p. 100 of Papers on the Geology of Western India edited by Mr. Carter].

† Pl. vi., fig. 4.—*Section of Gidad Hill.*—*a*, Freshwater deposit, as seen in the plain, of a white colour; *b*, Freshwater deposit of red colour under the terrace, *c*, Freshwater deposit higher up, brownish green in colour.

again. In ascending the Ghát to Gáwilgad Fort, which, however, is beyond the limits of our map, the same thing may be observed. The slope is so steep that the road is carried in a winding direction up its face, and, although there are no terraces, yet, if I remember right, the traveller comes upon our deposit, which is there of a deep red clay as at Kátol, three or four times successively.

From the remarks now made it will be inferred that the stratum in question is extremely varied. Not only is it of all colours and all mixtures of tints, but it is of all kinds of substance and all forms of structure. At one place it is calcareous, at another siliceous, at a third clayey, and at a fourth a compound of all three. Here it is soft, and there indurated; frequently the upper layer, which is next the overlying trap, is hardened, while the lower part remains unchanged. Here it is crystalline, there cherty, and elsewhere scoriaceous. In one spot it is full of fossils, in another neighbouring locality it is utterly devoid of all traces of ancient life. In one part of a hill we see it six feet thick, but as we follow its line along the face of the escarpment we may witness its reduction to little more than an inch. I know not one constant feature that is characteristic of it. In judging of its identity, a very useful guide to follow is its position between the nodular trap above and the vesicular trap below; but even this, as we have seen, fails us on the outskirts of the formation. Extensive experience, that enables us to combine several criterions that would singly be insufficient, is here, as in so many other cases, the only sure help towards arriving at a correct decision.

The greatest depth of the underlying trap, from its lower part being generally concealed, it is impossible to ascertain. It is obvious that according to its greater or less development the plain rises into a gentle swell or increases to the dimensions of a hill. Near Tákli, at the spot where almost all the fruits have been discovered, it is only a few inches thick, and a few yards from that locality it thins out altogether; whereas at Sitábaldi Hill, where it is observed to rest on sandstone, it attains a thickness of 100 feet; and in hills where its superposition on the sedimentary rock cannot be seen it must be a great deal thicker.

I have been thus minute on the appearances exhibited by the overlying and underlying trap, and the deposit enclosed by them, in order that we may have a clear idea of their relation to each other. The conclusions to be derived from my description I need scarcely indicate. It is quite evident that, before either of the volcanic rocks was poured

out in our area, there had been deposited on the sandstone a stratum which must have been at least six feet thick. Over this there was spread a molten mass of lava, which hardened the surface of the stratum, and itself cooled into a flat sheet of globular basalt about 20 feet thick. After a period of repose the internal fires again become active and discharge another effusion, which insinuates itself between the sandstone and the superior deposit; and, accumulating in some parts, more than in others, through force of tension, ruptures the superincumbent mass, tilting up the stratum and scattering the overlying trap, or, raising both stratum and trap above the level of the plain, either leaves it a flat-topped hill, or, with boiling surge, pushes up its summit gradually or by fitful effort. In these convulsions the more recent trap, where it has not tilted up the deposit altogether, has generally encroached upon it, entangling some of its fragments, converting the greater portion of it into a crumbling vesicular rock, or producing miniature outliers of amygdaloid from materials susceptible of the change.

[*Fossils.*—As the detailed description of the fossils of the tertiary formation and of the older sandstone series will form the subject of Part II. of this memoir, and be published hereafter, the fossils of the freshwater deposit are here merely referred to in short.

From the collections made by Messrs. Hislop and Hunter and their friends from this deposit,* the authors mention the following organic remains:—

Small bones, probably reptilian.

Remains of a freshwater tortoise.

Fish-scales, both Cycloid and Ganoid, in great numbers.

Insects, found at Tákli: Mr. Hunter enumerates about ten species of *Coleoptera*.

Entomostracans; five or six species of *Cypris*.

Mollusca, land and freshwater, in great numbers. The following genera are enumerated:—

Bulimus.†	Melania,	Limnæus.
Succinea.	Paludina.	Unio.
Physa.	Valvata.	

* An extensive series of organic remains and of rock specimens from the superficial deposits, the tertiary beds, the fossiliferous sandstone and shales, and from the crystalline rocks, has been presented to the Society by the author of this memoir. The fossils, however, have not yet been fully worked out.—Mb. Quart. Journ. Geol. Soc. Lond.

† I am now inclined to doubt the occurrence of Bulimus in our tertiary strata.—S. H.

Plant-remains: Mr. Hunter enumerates—

Fruits and seeds, about fifty species.
Leaves, exogenous, six forms.
„ endogenous, three or four.
Stems, exogenous, few species; some specimens six feet in girth.
„ endogenous.
Roots, six or seven kinds.
Chara, seed-vessels.

In concluding his notice of the tertiary insects and plants, Mr. Hunter observes—

"Before quitting this part of the subject, it may be observed that it would not be difficult to conceive with some degree of accuracy the nature of the locality in which the fruits grew. Going back to the tertiary epoch, we find Tákli part of a lake extensive enough to be bounded at least on the west and south, and probably on all sides, by the horizon. We assume rather than can demonstrate the existence of islands which break the uniformity of the sea-like expanse of waters. On the higher land of these are forests, mainly of exogenous trees, some approaching six feet in girth. More scattered, but yet sufficiently numerous to attract notice, are palms, exhibiting on their stems, when closely examined, protuberances of aërial roots, similar to those so frequently observed on the Wild Date of India. In the more shady valleys are leguminous and other plants, in great variety and profusion; and there may be seen occasionally climbing by numerous tendrils over the bushes, a cucurbitaceous plant allied to the *Luffa*, its tender stalk weighed down by a ponderous and probably ten-angled fruit. The *Nipadites* here and there fringes the marshy shores; and wherever the water is shallow there rise above it the reedy peduncles of Aroid plants, terminated at one season of the year by spikes of flowers, and at another either by long succulent purple fruit, resembling mulberries, or by large pericarps, that without minute examination might be mistaken for cones.]

Age of the Freshwater Deposit.—It has already been shown by my esteemed colleague, in his concluding observation on the tertiary plants (*see* above), that the body of water in which the strata containing the above-enumerated fossils were deposited must have been a lake. I shall now inquire at what period that lake existed. The determination of this question is attended with peculiar difficulties. In a temperate climate like Britain, the discovery of a large number of organisms fitted for a tropical abode at once demonstrates that the rock in which they

occur cannot have been deposited subsquently to a remote tertiary period. Here, however, where we have a tropical heat at the present day, the evidence derived from such a source is much more equivocal.

Still I think there are sufficient dissimilarities between our recent and fossil floras to prove the great antiquity of the latter. While there is a general resemblance between the two, inasmuch as *Hedysareæ*, *Cassiæ*, *Luffa*, and *Nipa* are comprehended in both, there may be remarked, on the other hand, the total extinction of two genera, if not an order, of endogenous plants, that once flourished luxuriantly here,—I refer to the Mulberry-like and strobiliform fruits, which, though formerly so abundant, have at present no representative either in India or, so far as I know, throughout the world. We must therefore direct our thoughts to some period comparatively remote, when there was a greater uniformity of temperature over all parts of the earth. Of the more ancient tertiary floras none corresponds with ours so well as that of the London Clay of Sheppey and Belgium. In both of these localities we find *Nipadites*, and in the former also the *Xylinosprionites* and *Tricarpellites* of Bowerbank, fruits apparently allied to those found at Nágpur.

Of all the animal remains we have collected, scarcely one seems to be identical with forms now existing on the surface of the globe. The nearest approximation to specific identity is in one of the *Cyprides*, and in the minute discoid *Valvata*; but whether the identity is complete I am not competent to say. Supposing, however, that it were proved to be so, this fact would merely show that of all the living tribes inhabiting the waters or the margin of our old-world lake, not one has survived in India except a single species of *Cypris*; for the *Valvata minuta* is not now found here, nor indeed does any species of that genus appear to occur throughout Asia. But with these most diminutive exceptions, if exceptions they are to be called, the statement holds good that between our ancient and our modern fauna the agreement is not closer than generic. In the class of fishes the resemblance even to that extent is true only of one order,—the Cycloidans; while the other order, the Ganoidans, which have left their horny and bony scales so abundantly in our rocks, have entirely disappeared from our rivers and tanks. Of the class Mollusca, while the genera *Planorbis* and *Ampullaria*, now so common in our pools, are altogether absent from this deposit, *Valvata Physa*, so extensively represented in it, both in species and individuals, have disappeared from the plains of Central and Southern India. Of the six genera *Melania*, *Paludina*, *Limnæus*,

Bulimus, *Succinea*, and *Unio*, which are common to both ancient and modern India, the differences between the recent and fossil species, specially in the *Paludina* and *Limnæus*, are very great. Of the former we have nothing at all so large as the *P. Bengalensis* of the East, or even the *P. vivipara* of Britain. In the latter genus none of our species appear to have belonged to the inflated type, but they are generally more on the model of the *L. glaber* than that of the *L. stagnalis* of our native country.

Combining, then, these facts, on the one hand we have the total dissimilarity between every species of our ancient and modern plants,—the disappearance from our flora of several genera, if not of something higher—the difference in prevailing type between some of our fossil and existing genera of molluscs, and the removal of others entirely from our continents to regions most remote,—and lastly, a still more decided transference among the orders of our fishes,—data which all point to the negative conclusion that it is no newer tertiary that can be compared with our freshwater deposit. On the other hand, we find generically, specifically, and individually an equality, to say the least, between our Ganoid and Cycloid fishes, and a resemblance between our flora and that of the London clay,—proofs which, in my opinion, lead us on to the positive inference that among older tertiaries the eocene formation is that with which our freshwater deposit must be classed. Bronn, I perceive, assigned it to the era of the continental molasse. Whether or not the statements above made will be sufficient to show that this view is incorrect, it is not for me to say; at all events the fossils which we have contributed will enable others to decide.

Extent of the Freshwater Formation.—The extent of this tertiary freshwater formation throughout India is very great. In Captain Sherwill's recently published Geological Map we find it laid down on the west of Rájmahál, on the Ganges. Following the same parallel of latitude, we come to Ráe, near Narwár, about forty miles south of Gwáliur, whence specimens of *Physa* were obtained by Mr. Fraser, formerly Agent to the Governor General in the Ságar and Narbaddá territories. At Ságar itself organic remains were first discovered by Colonel Sleeman, afterwards described by Dr. Spry, and more recently investigated by Captain W. T. Nicholls of the 24th Regt. M. N. I. East of Jabbalpur, in the same territories, occur the sites Suleyá, where Dr. Spilsbury procured *Physa* in 1833, Dhunra, in the same vicinity, Náráyanpur, near Sohájpur, Mandla, and Phulságar, on the north bank

of the Narbaddá, and as far up the river as Mohtura and Domádádar, in the Rámgad Rájá's country, at all of which localities the same indefatigable and successful geologist found shells, including an abundance of *Physa*, several specimens of *Unio*, and, if I may judge from the figures, of *Limnæus* and *Valvata*. None of them, however, are named.* North of the Narbaddá, near Mándu, univalve and bivalve shells abound in the marls and earthy limestone, as we learn from Captain Dangerfield, who styles them "Buccinum and a species of Mussel"† (*Physa* and *Unio ?*).‡ Leaving the Narbaddá and coming to the Tapti, near its source, we find that Voysey, as has been mentioned by Malcolmson, in his memoir on this deposit, discovered shells, which he named "Conus and Voluta" (two forms of *Physa ?*), at Jirpa and Jillan, which lie apparently on the north of the Gáwilgad range.§ On the S. of the same chain of hills, near Elichpur, are Muktágirí and Bairám, whence Dr. Bradley procured the excellent specimens of *Physa* and *Unio* which I had the pleasure of sending to the Geological Society. Returning to Jirpa, we enter the district of Betul, about 100 miles NW. of Nágpur, which was explored by Captain Ouseley, who found shells at Chichundra and Murkha, on the E. of the town, at Bharkáwádá, Bheiáwádá, and Jáwará on the S., and at Badori, Kolgaum, Gaikhan, and Bákur, on the SW. Passing over the localities within the State of Nágpur, to which sufficient reference has been made in the previous part of this paper, we arrive at the district north of Hyderabad, where, I am informed by a friend, *Physæ* have been extracted from one of the banks of the Godávari at Nándur, and where also fossils were discovered near Hatnúr and Manúr by Malcolmson, and at Medkondá, Shiwalingapá, and Deglur by Voysey, who as early as 1819, when organic remains were almost unknown in India, met at these localities with shells, including, as he thought, "Turbo, Cyclostoma, Buccinum, Helix, and Turritella," some of which may be identified as *Physa* and *Valvata*. Not far from Deglur, on the S. side of the Manjará, Captain Newbold obtained specimens of *Physa* at Munapilli,¶ and again from between Kulkonda and Digái, on the banks of the Bhima, he was presented with specimens of *Paludina Deccanensis* by Captain

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* Bengal As. Soc. Journ., vol. viii., p. 708.

† *Physæ* and smaller univalves are common at Jam Ghát, midway between Mhow and Mundlesar.

‡ Malcolm's Central India, vol. ii., p. 329.

§ Trans. Geol Soc., 2nd Ser., vol. v., pp. 570, 571.

¶ Bengal As. Soc. Journ., vol. xiii., p. 987.

Wyndham. These are all * the fossiliferous localities for our tertiary formation with which I have become acquainted, with the exception of Bombay, and Pangadi near Rájámandri, afterwards to be more particularly noticed. But besides these there are many places where the same deposit occurs destitute of organic remains. For example, my friend Mr. Hunter and myself, on a Mission tour, traced it almost without interruption from the vicinity of Núgpur, where the fossils cease, westward to Elichpur, a distance of 100 miles and upwards; and while the material of the rock was sometimes a whitish lime, and at others a green or a red clay, we were uniformly unsuccessful in finding in it any kind of fossils. Similar differences are exhibited in the unfossiliferous stratum around Shiwani. At Garhákotá, near Ságar, thence to Tendukheda, on the Narbaddá, wherever Major Franklin met with trap he "always found it in association with earthy limestone."† The experience of Captain Dangerfield regarding its position was somewhat different, he having met with it in certain parts of Málwá, as "a thin bed of loose marl, or coarse earthy limestone," "near the bottom of the small hills and banks of the rivulets."‡ The country between the Wardhá and the trap region described by Colonel Sykes has not been examined by any geologist, so that no site can be named in it for our lacustrine formation except Jálná; but I remember noticing it on my first arrival in India, nine years ago, at many localities, though I have now forgotten their names. But when we come to the scene of Colonel Sykes's efficient labours § we can trace it almost everywhere, under the name either of "ferruginous clay" or "pulverulent limestone." The stratum of "red ochreous rock," varying in thickness from an inch to many feet, and in texture from friable to compact earthy jasper, occurs at Nandur and Jihar, near Ahmednagar; at Kothul; in the scarps of the hill fort of Harichandargad, and a mountain near Junir; and at Sirur, Wángi, and Barloni, between which two lastmentioned places the bed is believed to be continuous. Finally, it occurs abundantly on the Ghâts, frequently discolouring the rivulets, and giving a ferruginous character to the soil over a considerable area. ||

* I have since read of the discovery of a gyrogonite in a white aluminous shale, which was cut through for the railway between Madras and Bangalore. Wishing to learn whether this chariferous deposit was of the same age as ours, I wrote to the author of the announcement referred to, but received no reply. If it is contemporaneous, this will carry our tertiary formation 200 miles further south than any locality at present known.

† As. Res., vol. xviii., pl. i., p. 38.

‡ Malcolm, vol. ii., p. 328.

§ Geol. Trans., 2nd Ser., vol. iv.

|| Geol. Trans., 2nd Ser., vol. iv., p. 419.

Pulverulent limestone is generally found in layers, varying from an inch to three feet in thickness, and covered by a few feet of black earth. Examples of it are met with at Jihur and Islampur, near Ahmednagar; at Karkamb and at Salsee, ten miles S. of the fortress of Karmali.* Crystalline limestone, which occurs as an imbedded mineral in amygdaloid,† and "great masses of mesotype,"‡ which are found in a similar position, seem to me, if I may judge from the analogy of the district of Nágpur, to be instances of our formation somewhat transformed. The ochreous rock or ferruginous clay above mentioned was discovered by Newbold at Sindaghi, in the Southern Marátha Country, which lies south of Colonel Sykes's district, and it was described by him as "finely laminated bright red bole," from three to six feet thick.§ And this is most probably the origin of the "red clay," which Newbold on analysis found to be the basis of the amygdaloid in which zeolitic crystals abound.¶

The strata of Bombay have been described in an able and luminous manner by Mr. H. J. Carter, of the Bombay Medical Service.‖ In thickness they greatly surpass anything we meet with in Central India, reaching to between 40 and 50 feet, and they are peculiar in having a little carbonaceous matter covering some of the vegetable remains. The fossils themselves, however, whether animal or vegetable, bear a remarkable resemblance to those which have been brought to light at Nágpur. Thus we find among them a freshwater tortoise,—the elytra of insects,—an abundance of *Cyprides*, one species of which appears to correspond with the *C. cylindrica* (Sow.), first found by Malcolmson,—a few indistinct impressions of shells like *Melania*,—fruits and seeds, though not of the same genera as ours,—ensiform endogenous leaves, like the Nágpur specimens,—corniform roots, which differ from ours only in being larger,—and an abundance of dicotyledonous wood.

At Pangadi or Peda Pangadi, near Rájámandri, not far from the mouth of the Godávari, there are found some outlying trap hills, which General Cullen pointed out to Dr. Benza as fossiliferous. That gentleman visited the place, and decribed one of the eminences as consisting at its base of sandstone, which is overaid by amygdaloid veined with

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* Ibid, p. 420.
† Ibid., p. 425.
‡ Ibid., p. 421.
§ Royal As. Soc. Journ, vol. ix., p. 38.
¶ Ibid., p. 35.
‖ Bom. Br. R. As. Journ., vol. iv.

jasper, then a limestone deposit with fossils, and finally a shoot of basalt. The fossils were stated by Dr. Benza to be partly marine and partly freshwater; but as his statement was made at a time when not much attention was paid to the distinction between these two classes of shells, it was supposed that it might be incorrect. I confess that I myself was guilty of this wrong to the memory of an able geologist. However, I took steps to discover the truth, and through my friend Lieutenant Stoddart, employed in connection with the Godávari public works, I have ascertained, I am happy to say, that Dr. Benza is substantially right. His oysters were real oysters, though his "Ampullariæ" most probably belonged to some species of *Physa*. "On only one of these hills," says my intelligent informant, "could I find any oysters; but there, I must say, they were as plentiful as stones." At the foot of a hill opposite to this, Mr. Stoddart found several kinds of shells, and among them a *Physa* identical with a species common around Nágpur which was in the same block with a *Chemnitzia*. There seems to be a great variety of molluscous remains at this locality, and it would well deserve a longer investigation than my kind friend was able to give it.*

Here, then, we have the best proof which similarity of position and specific identity of contained fossils can afford, that the deposit enclosed in trap at Pangadi is properly contemporaneous with our freshwater deposit in Central India, although a majority of its organisms are truly marine. It is evident that it was here our great collection of fresh water, stretching, either in one continuous sheet or interruptedly, a distance of 1,050 miles, in a direct line from Rájmahál to Bombay, and of 660 miles from N. to the neighbourhood of Pangadi, discharged itself by an estuary into the sea. Whether this great expanse of fresh water was one or many lakes cannot now be determined, in consequence of the disappearance of trap from many situations where once it must have existed; but I am persuaded that the more careful the exploration made in the great basaltic region of Western India, the more evident it will become that the intervals between the lakes, if any there were, must have been exceedingly small. This was the conviction left on my mind by travelling from Nágpur to Elichpur, and this I think will be

* A small series of fossils from Pangadi sent by the authors comprises *Ostrea, Cardium, Venus, Chemnitzia, and Nerinæa ?*—Ed. Quart. Journ. Geol. Soc. Lond.

More recently I have been favoured with a sight of the fossils from Káleru, two miles N. of Rájámandri, presented by W. Elliot, Esq., to the Bengal Asiatic and Madras Central Museums. They include two species of *Cardita*, four of *Cerithium*, and a *Monoceros* or *Pseudoliva*; but none of them appear to agree with a species at present found in our Indian Seas.—S. H.

the feeling produced in the mind of any one, by taking a glance on a map at any district, like Colonel Sykes's, that has been surveyed, even without a reference to a lacustrine deposit.

Minerals in the Trap.—I ought now to describe the minerals contained in our overlying and underlying trap; but this has been so well done by Voysey, in his remarks on the structure of Sitábaldi Hill,* that it is unnecessary. One of the most common in the locality just named, though elsewhere rare, is a pitchy black substance, with a sloe-like bloom upon it, lining the amygdaloidal cavities. This Voysey appears to have called "conchoidal augite:" my friend Mr. Carter supposes it obsidian. It occurs in bands lying one above another, which may be followed to a great distance in a horizontal direction. The intermediate spaces seem as if they had been successive effluxes of volcanic matter running along beneath the freshwater deposit, and then under one another, each efflux being united or welded to the preceding one by a vesicular belt. Many of the minerals that are met with in the amygdaloid are derived from the tertiary strata. This is particularly the case with jasper, the veins of which, as may be learned from Benza's description of Padpangali Hill, and, as we perceive in numerous places in this vicinity, are situated just at the zone of the vesicular trap's intrusion on the superior deposit. Sometimes, instead of being jaspidified, the entangled parts of the strata are converted into chert, at other times they are crystallised into ponderous masses of mesotype. In one locality the calcareous matter is diffused as strings all through the amygdaloid, forming seams of kunker, like those represented by Newbold;† in another they are scarcely enclosed within its substance, but remain in blocks at the lower part of the deposit, which are compact externally, but in the interior, where the heat has continued longest, are found to be an aggregation of crystals.

On the plain south of *Gidad* hill there is, lying about, a great abundance of spherical nodules, which on being broken up exhibit a structure radiating from a central point, so that they have been mistaken for Alcyonites.‡ The fakírs, who have located themselves on the top of the eminence, have adroitly taken advantage of this natural phenomenon to exalt the name of the saint whose disciples they profess to be. These nodules, according to them, are so many fruits and spices of different sorts, which Shek Farid converted into stone, the largest having once been cocoanuts, the middle-sized betelnuts (*Areca*), and

* As. Res., vol. xviii, p. 123.

† Royal As. Soc. Journ., vol. ix., p. 38. ‡ Journ. Ben. As. Soc., vol. ix., p. 625.

the smallest nutmegs. There is a resemblance of the nodules to the last two natural productions; but, as all alike display an acicular crystallisation, it is difficult to trace the similarity of the largest to the fruit of the cocoa. Much light must be introduced into this land before the inhabitants shall be convinced of the falsehood of the alleged miracle, and shall be able to understand that the seeming organisms are simple zeolitic concretions that have issued from the soft subjacent rock. Nodules of the same shape are found in the same formation at Sonegaum, near Kalmeshwar, fifteen miles NW. of Nágpur, but, being purely calcareous, their interior consists of a confused mass of rhombic crystals.

The Age of the Trap.—Beginning with the more recent, as we have done in regard to the stratified rocks, we find that the amygdaloid or underlying trap has not only invaded the tertiary formation, but broken it up, and along with it the nodular basalt by which it is capped. The amygdaloid eruption, then, is incontestably subsequent to the basaltic. But what age is to be assigned to the latter? It is evidently posterior to the freshwater beds on which it rests. We have thus an overlying effusion of nodular basalt, which has taken place after the tertiary strata, and an underlying intrusion of amygdaloidal trap, which has occurred after the basaltic effusion. Besides these two formations of trap I know of no others in Central India, either more modern or more ancient. Captain (now Colonel) Grant, in his paper on the Geology of Cutch,* and Mr. Carter, in his memoir on the Geology of Bombay before quoted, have adduced ample proofs to show that in the districts which they have examined, there have been eruptions of volcanic matter subsequent to the amygdaloid; but in all the districts through which my colleague and myself have been called to travel no trap formation so modern has fallen under our observation. Nor has any more ancient than the overlying trap been discovered. It might be thought, from the occurrence of isolated pieces of trap in the lower part of our freshwater strata, that while these were being deposited there were sheets of volcanic rock already on the surface of Central India. But it appears to me that there are no such fragments whose existence may not be accounted for on the principle explained by Lyell in his Manual, 4th edition, p. 446, and stated in a preceding page of this paper. Besides, at Bhokára and some parts of Tákli Plain, where the amygdaloid has not been intercalated under our tertiary formation at all, but where the latter, with its characteristic fossils, rests immediately

* Trans. Geol. Soc., 2nd Ser., vol. v.

and conformably on the sandstone, there is not a trace of volcanic matter to be seen. I am inclined, therefore, to doubt the occurrence of any trap in Central India older than our lacustrine deposit. In the southern portion of the Rájmahál hills M'Clelland* informs us that amygdaloid is found underlying the coal strata of that district. The coal there is manifestly the usual so-called oölitic coal of India, and therefore we have amygdaloid disturbing the jurassic formation. But, if a stranger to the locality may be allowed to express an opinion, I would respectfully submit that the position of the amygdaloid is not conclusive against its comparatively modern origin. It is obvious that the most recent age attributable to an intruded rock, such as it is, cannot be exactly determined by observing what strata it has disturbed in one district; for it may have invaded an older formation in one locality, and yet, rising higher, it may have broken in upon a newer formation in another place; or, applying the principle to the case in hand, the very same amygdaloid which M'Clelland calls secondary trap, because it has been erupted among the oölitic strata of Rájmahál, may be tertiary trap here, if it is, as I believe, the identical effusion which has been intercalated between the oölitic and tertiary formations of Nágpur. But for the conclusive determination of this question the district of Rájmahál, with a tertiary formation found in connection with trap in its northern part, and jurassic strata associated with trap in its southern part, presents the most befitting arena.

Mode of its Eruption.—Before leaving the volcanic rocks it is desirable to indicate the lessons which Central India teaches as to the manner in which they were formed. Now, the first thing which strikes any observer of the great basaltic field of this country is the comparative absence of all cones or craters throughout. I cannot name a spot in all the tract with which I am acquainted where I could say either the nodular basalt or the amygdaloid came from below. The nodular basalt seems to have flowed along for immense distances, filling up the tertiary lake and leaving an arid plain in its rear. Then the amygdaloid, inserting itself between the sandstone and the freshwater bed, seems to have flowed generally underground on the same scale of grandeur. Sítábaldi Hill, which is almost an outlier of the great basaltic region of Western India, being connected with it by a very narrow neck, would be a favourable place for ascertaining whether the underlying trap which has there accumulated under the tertiary deposit to a considerable thickness, has been forced up vertically through the gneiss and sandstone,

* Report Geol. Survey of India, Season 1848-49. Calcutta, 1850.

which appear around the base of the hill to be inferior to it, or whether it has been horizontally intercalated, as in the generality of places between the sandstone and the tertiary. I am disposed to take latter view; but, if the Government quarry were only excavated a few feet lower, as Voysey long ago suggested, it would put an end to all doubt.*

From the statements previously advanced regarding the trappean rocks of Nágpur, taken in connection with the same formation in other parts of the country, it is obvious there is no foundation whatever for the supposition that the great outpouring of basalt in India took place in the ocean. And, although I believe that the fresh water in which is really was effused must have stretched over great areas without much interruption, yet the discovery in the tertiary strata of abundance of pulmoniferous molluscs, such as *Limnæus* and *Physa*,—of plants, such as marsh or shallow-loving Endogens, buried with their roots and fruits almost entire, and therefore not far from the spot where they originally grew,—not to mention the occurrence of an amphibious univalve like *Succinea*, and of land-shells like *Bulimus*, together with great quantities of seeds and fruit and timber, the spoils of the neighbouring dry land—plainly shows that the water in that part of the lake was of no great depth. Indeed it seems obvious that in places not a few the water of the lake must have been so shallow as to allow the igneous rock which was poured out over its bottom to rise above its surface into the atmosphere. We must resort, then, to some other hypothesis than aqueous pressure to explain the horizontalness of our trappean hill-tops, and a cause adequate to the effect is the well-known law by which the surface of liquid bodies is reduced to the same uniform level. To this law volcanic matter is subject in spreading over an area either of land or water. If to this it be objected that then we should expect the surface of the effusion to appear scoriaceous like modern lavas, it may be replied that naturally all such light materials in the lapse of ages would be worn away.

VII. *The Sandstone Formation.*

Under the amygdaloid, or, where it has not been intercalated, immediately under the tertiary freshwater strata, is found an extensive series of rocks consisting chiefly of arenaceous beds.

A. The upper member of this series is seen at the foot of Sitábaldi Hill, passing into gneiss, into which much of it, as well as most

* It has since been ascertained that the sandstone underlies the lower trap about the middle of the hill, and it may be warrantably supposed to do so throughout.—S. H.

probably all the lower members, have been converted. Without enumerating all its localities, I may mention that a good section of it is presented by a rivulet skirting the Lál Bág, where the layer under the nodular trap has itself been rendered distinctly nodular. It may be observed in the western division of the city of Nágpur; and it stretches in some places under the amydgdaloid, in others under the tertiary bed, but for the most part as the surface-rock, through Tákli Plain to Bhokára. At Nágpur and in Tákli Plain the strata are of friable sand intermixed with kunker, and variegated with a deep irony-red and occasionally a purple colour. But it is at Bhokárá where we can understand it best. In one of the quarries there we find it as at Nágpur, only with less of the colouring matter. Going northward to another quarry, we see it on the way overlaid by the lacustrine formation before described, which is capped by a small rise of nodular trap. Arrived at the quarry, which is only about 100 yards from the first, we find the same upper member of the sandstone, now, however, no longer soft and crumbling, but so hard that the hand millstones of the country, which resemble Scottish *querns*, are derived from it; and the ferruginous matter, instead of being diffused as blotches, is gathered into waving iron bands more indurated still. At this place those upper beds, which are about 25 feet thick and very coarse, contain angular fragments of a finer sandstone which lies below. Near Bázárgaum the strata, where exposed, are pierced with irregular holes, which seem to have been caused by the action of rain and the atmosphere. At Kámpti, situated towards their top, and rising even to the surface through the soil, are imbedded huge blocks, some of them angular, but most of them rounded and waterworn, which contain almost all the fossils that have been procured from that interesting locality. At Silewádá, towards their lower part, there occur a considerable number of compressed stems of trees *in situ*, one of which, presenting its thin edge in the side of a quarry, may be traced for about 20 feet. A few inches further down we come to the largest of the iron bands, which consists of a conglomerate, about six inches thick, enclosing fragments of dicotyledonous wood converted into a kind of jet, and impregnated with iron. Ferruginous bands are common not only at Silewádá, but also at Bábulkedá and Tondákheiri. It is only, however, in the neighbourhood of Chándá that any one of them has been found to contain wood in a silicified state.

B. Underlying the iron band we come to layers of a much finer kind consisting of argillaceous sandstone, varying from white to yellow and

pink, and generally containing specks of mica. These strata, which are used for pavement and carved work, extend downwards for about 15 feet, when they gradually become coarser, until they are suitable for millstones. The entire depth of these layers, after their change from fine to coarse, has not been ascertained. Dispersed through them, as we saw was the case with the upper member, are occasional angular fragments, so that it is difficult to distinguish lithologically between the two, except that the inferior beds always contain less oxide of iron than the superior.

It is in the argillo-arenaceous strata that we have met with nearly all the fossils which the sandstone of Silewádá, Bhokárá, Babulkhedá, Bharatwádá, Tondákheiri, Bázárgaum, Chorkheiri, and Chándá has yielded; and there is every reason to believe that the imbedded blocks of Kámpti also, which have furnished so many vegetable remains, were originally derived from them.

Chorkheiri and Chándá are the furthest limits north and south from which I have procured fossils of the inferior member of the sandstone; and the fact that the fossils are exactly the same, in addition to a resemblance in lithological characters, demonstrates that the strata are so also.

Between these two extreme points, however, under an outcrop of coarse sandstone of much the same character as the generality of our upper beds, except that it is not coloured by iron or pervaded by iron beds, there are found at Mángali and its neighbourhood fossiliferous strata applied to the same architectural purposes as our ordinary lower strata, though they differ from them in being of a deep red colour, finer and more sectile, and with a larger admixture of clay and mica. As the Mángali red slaty sandstone contains scarcely any organic remains common to the inferior layers about Nágpur, it is not without hesitation that I include it under the present head, and arrange its fossils along with those of the more typical strata.

[*Fossils of* B.—For the same reasons as stated above, p. 268, in the case of the palæontology of the tertiary deposits, the numerous fossils of this division of the sandstone series are here merely mentioned in short, their detailed description being deferred until the publication of Part II. of this memoir.

These fine and coarse argillaceous sandstones, rich with plant remains, have afforded—

Labyrinthodont Reptile* (from Mángali).

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* The *Brachiops laticeps*, Owen. See Quart. Journ. Geol. Soc. Lond., vol. x., p. 474; and xi., p. 73, pl. 2 [and this vol., p. 288.—H. J. C.].

Fishes ; small jaws and ganoid scales.
Crustaceans ; *Estheria.*
Plant remains.
Fruit and seeds ; numerous and undescribed.
Leaves ; Conifer, Zamites, Poacites, and Ferns (*Pecopteris, Glossopteris, Tæniopteris, Cyclopteris, Sphenopteris*).
Stems ; exogenous and endogenous.
Acrogens ; *Aphyllum, Equisetites, Phyllotheca, Vertebraria.*]

c. Between the sandstone quarries at Bhokárá and Korhádi granitic rocks have lifted to the surface, with a dip of 30° to SW., a series of red shaly beds ; and between these and Bhokárá another species of green argillaceous strata, lying somewhat more horizontal. The relation of these two to the sandstone beds, from the absence of any good exposure, I have not been able to ascertain , but they would appear to underlie it. Besides the locality now named, these rocks are developed in the district north of Chándá, but they require to be distinguished from the green shale in the vicinity of the Mahádewas, which is associated with the beds of Indian coal, and rightly classed under the sub-division b. The red shale at Korhádi has yielded the following organic remains :—

Fossils of c.—A reptilian footmark of one-third of an inch long, and as much broad. Three or four specimens have been obtained, each exhibiting only one print ; owing to the brittleness of the matrix, I am not sure that all the impressions are of the same kind.

On the same specimens that bear these footmarks are seen the tracks of wormlike animals. That the animals forming these tracks have been Annelids, resembling earthworms, will be evident to any one who considers the appearance of the furrows, the way in which the head has occasionally been pushed forward and then withdrawn, the tubular holes by which the ground has been pierced, and the intestine-shaped evacuations which have been left on the surface. Fossil worm-borings have been found in the green shale of Tadádi, NW. of Chándá, seventy miles S. of Nágpur.

The only vegetable organism which has been discovered in the shale is a sulcated plant, which most probably belongs to the genus *Phyllotheca ;* but, as a sufficient length of the stem has not been obtained to display the articulation, its precise character cannot be fixed.

b. Immediately below the red shale there are found beds of white marble at Korhádi, which have been greatly disturbed and dolomitised

section obtained by Dr. Bell * we find sandstone, from 50 to 500; argillaceous limestone, 9 feet; and, after various unimportant argillaceous, bituminous, and calcareous strata, in all 4 feet; limestone 1 ft. 9 in.; laminated sandstone and shale, 8 feet; and argillaceous &c. strata as before, 11 feet 8 inches,—we come to limestone, 23 feet; then argillaceous and calcareous beds, 25 feet; red clay 27 feet; and limestone." Here it would appear that shale, sandstone, and limestone are interstratified.

Though there is no great development of carbonaceous beds in the district which is the more immediate subject of this paper, yet I should regard the communication as incomplete without some notice of the position of the Indian coal in reference to our sandstone strata. Bhuwán, in the north-west of our area, at the foot of the Mahádewa hills, furnishes us with a common term of comparison.

Thickness of the Strata.—A. The highest beds, as exposed in the quarries of Silewádá and Bhokárá, average about 25 feet of coarse sandstone, with iron bands, below which there are 15 feet of argillaceous sandstone, B, with an abundance of fossils, and an undetermined depth of coarse sandstone beneath. These constitute what Mr. Carter, in an able Summary of Indian Geology which I have just received, calls the "Pannáá" sandstone. From outcrops of this sub-division of the sandstone series in other localities near Nágpur, the whole thickness of the highest beds may be reckoned at about 200 or 300 feet. At Kotá, as we have seen, it ranges from 50 to 500 feet; at Mudalaity 120 feet; and at the Mahádewa hills, according to Mr. Sankey, 2,700 feet, which must be its greatest development. C. The depth of the shales at Korhádi and Tadádi seems to be—green about 30 feet, red 50 feet. At Kotá, omitting interstratified argillaceous limestone and sandstone, all the argillaceous thin strata united amount to 29 feet, red clay 27; while at Newbold's section of Mudalaity, where the shales, usually reddish, underlie the limestone, they attain a thickness of 50 feet. D. The limestone which underlies the shale has been much disturbed by granite at Korhádi, so that we cannot fix its thickness precisely; but I should think it cannot be less than 100 feet—at Mudalaity it is 360 feet. Under this limestone, which is included in Mr. Carter's excellent paper along with shales and coal under the name of Kattrá shales, there occurs, as Newbold has shown in Southern India, and Franklin in Bundelkhand, another series of sandstone rocks, for which Mr. Carter proposes the name of "Tará" sandstone; but as, most probably owing to the

* See also Quart. Journ. Geol. Soc, Lond., vol. x., p. 374 and *note*.

intrusion of the granite, this member of the formation does not occur in our neighbourhood, I have nothing to say regarding it.

Character of the Formation.—There can be little doubt that the upper strata are lacustrine. The occurrence in them of such an immense collection of terrestrial vegetation, intermingled with *Poacites*, taken in connection with the total absence of Fucoids and other marine plants, shows very plainly that they must have been deposited in fresh water. And, as no river could have covered the extent of surface which these beds occupy, we are bound to conclude that, like the tertiary rock previously described, they must have been formed in a lake, a conclusion which the discovery of *Estheria* (or *Limnadia*), with their two valves entire, and congregated together as they are found in their usual haunts, fully justifies. Again, the abundance of worm-tracks and borings in the red shale of Korhádi, and the green shale of Tadádi, renders it more than probable that the strata at these localities constituted the margin of an ancient lake, and not of a sea or even of a river. Of the origin of the dolomitic beds it is impossible to give any certain account, owing to the transformation which they have undergone, though we may suppose they follow the analogy of the other members of the formation. The character of the upper strata at Elichpur, as would appear from the fossils discovered by Dr. Bradley, is exactly the same as at Nágpur. The *Lepidotus*, which has been found at Kotá, from its association with terrestrial vegetable remains, has been pronounced to have been probably an estuary or inshore fish; but, as the genus also occurs abundantly in the freshwater strata of the Wealden, it may be presumed that the strata at Kotá are not of a different origin from those in our neighbourhood. This supposition is rendered more likely by the fact that while no marine vegetation is said to have been detected there, a piece of the shale which Dr. Bell kindly sent me bears the impression of a bivalve exceedingly like a *Cyrena* or *Cyclas*. Dr. M'Clelland seems to suppose that the Bardwán coal-measures were deposited in a sea, for, in the last plate of his Survey already referred to, he has figured a fossil which he has called *Fucoides venosus*; but any person who compares the plant there represented with the *Glossopteris* figured in his Plate xv. under the name of *G. reticulata* will, I believe, agree with me in considering both plants generically, if not specifically, the same. I infer, therefore, that there is no evidence whatever to prove that our sandstone, or the shale at Kotá, or the Bengal coal-measures, were deposited in the sea, but, on the contrary, every reason to believe that they were all formed in a large body of fresh water.

by the plutonic rocks above referred to.* Similar strata, but pink and blue, occur in the channel of the Pech at Gokala, a little above Parshiwani; and still higher up, at Nawagaum, it rises into a chain of eminences, which runs thence westward to Kumari. Following up the river still further, on its right bank we come to a patch of the same crystalline limestone at Dudhgaum, where it is in the vicinity of trap. To the east of this, at A'mbájiri, in Chánpur, it occurs again: but there, as in most of its other localities, the granite rises to the surface in the neighbourhood. Limestone is found also on the Lánji hills at Kunde and near Bhánpur, to the east of Hattá, but whether it is the limestone associated with sandstone, or just a calcareous phase of our freshwater tertiary formation, from not having visited the spot, I am unable to decide. It seems to be comparatively free from magnesia, in which it differs from the generality of the strata of which we are now treating. From the heat to which these have everywhere in our area been subjected in the process of dolomitisation, we need not expect to discover in them any organic remains. Newbold thought that he had found in certain cherty veins of limestone near Karnúl myriads of spherical Foraminifera. We have also veins of chert in the Korhadi limestone which exhibit appearances that might be mistaken for the same objects, but they do not seem to be really organic. The minerals most abundant in the dolomite are tremolite and red and yellow steatite, which last, when the surface of the rock is weathered, stands out in little prominences, as if it were a species of lichen.

The whole series of strata which we have designated by A, B, C, D, we conceive to be only sub-divisions of the same formation. They have been disturbed by the same granitic eruptions, and where fossiliferous bear a general resemblance to each other in their organic remains. But this mutual connection is more apparent when we compare the series within our area with strata beyond it. From Mr. Sankey we learn that the sandstone represented in the north-west corner of our map is succeeded, in a descending order, at Chotá Barkoie by bituminous shale with fossils and sandstone. and at Bhuwan, at the foot of the ascent to one of the Mahádewa or Pachmadi hills, by indurated green claystone and green shale, and bituminous shale with fossils. Again, below the sandstone in the south-east corner of the map, as we are

* This dolomite ought to be ranked with the metamorphic rock. The calcareous strata on the Lánji hills seem to be the only true representatives in our area of the argillaceous limestone of Southern India. In the Rágpur district, east of our area, argillaceous limestone abounds.—S. H.

informed by Dr. Bell, there occur argillaceous limestone, bituminous shale with fossils, and a few alternating layers of impure limestone and bituminous shale, until we come to a bed eight feet thick of laminated sandstone &c. Situated as our sandstone is between those two extreme points, and appearing to be a bond of connection between them, we might, *à priori*, expect that the intermediate beds would be of the same age as those at the localities on either side; and this opinion is confirmed by the appearance of the sandstone near Nágpur, which shares, with the sandstones of the Mahádewa and Kotá hills the distinguishing feature, first noticed in this neighbourhood, of being pervaded by ferruginous septa. These dark brown stripes, which in all their hardness protrude from the weathered surface of the enclosing rock. will be found, wherever they occur, a very good criterion of judging of the age of the sandstone. But besides identity in the arenaceous beds of our whole district, we can trace the same identity between the subjacent strata at Nágpur, Pachmadi, and in the Hyderabad country. The green shale at the Mahádewas and that at Tadádi are different.

At Kotá, according to a private letter with which I was favoured by (the late) Dr. Bell, red clay, of greater thickness than any stratum that was passed through, underlies the other shales which he has enumerated in his section,* and in localities further south Malcolmson states† that the shales on which the sandstone rests are blue, red, green, or pure white. The strata at Mundipár are metamorphic; and, as we are told by Newbold,‡ the sandstone of the Eastern Ghâts frequently "passes into red and green argillaceous and siliceous slates and laminated marls." I think, then, that, though inferring the identity of Nágpur sandstone with that of Southern India, from the occurrence of diamonds at Weirágad, Malcolmson's statement was wrong as to its grounds, yet it was perfectly correct as to its matter. The position of the shale in reference to the limestone seems to vary. At Korhádi it is the superior rock. Such also is its position at Bángnápilli, according to Malcolmson,§ and generally according to Newbold. In a section, however, of the pass at Mudalaity, given by the latter writer, we have the following order: "compact light-coloured sandstone, 120 feet; limestone, 310 feet; shales, 50 feet; laminar and massive sandstone. Whereas by the

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* Quart. Journ. Geol. Soc., vol viii., p. 232.

† Trans. Geol. Soc., 2nd Ser, vol. v., p. 543 [and this vol., p. 7.—H. J. C.].

‡ Journ. As. Soc., vol. viii., p. 167.

§ Malcolmson, *ut supra*, p. 541 [and this vol., p. 5.—H. J. C.].

Dr. M'Clelland's sentiments, which in 1846 were very decided as to the true Palæozoïc character of our Eastern coal,† seem to have remained the same at the period of his more recent publication on the subject, for we find him in his Survey, while admitting the Oölitic age of some bluish-white indurated clays at Dubrájpur, in the Rájmahál hills, nevertheless placing the shales, sandstones, and seams of coal of Bardwán, and of Mussinia and Kottikún, in the Rájmahal hills, as an intermediate formation, which he styles the "Coal-measure," between the Inferior Oölite mentioned above and what he supposes to be the "Old Red Sandstone." After deducting specimens of *Fucoides*, which I cannot, with the aid of his figures, distinguish from those of *Glossopteris*, there are seven genera, to which he refers as "Indian coal-measure fossils." Of these, four, viz., *Sphænophyllum*, *Poacites*, *Calamites*, and *Pecopteris*, he says are "common to the coal-measures of Europe." In the conclusion which would naturally be drawn from this statement I cannot concur; and hence it is necessary to review the grounds on which it is made. The three genera not mentioned are *Zamites*, *Taniopteris*, and *Glossopteris*. Of these the first two are held to be well nigh characteristic of the Jurassic period, while the remaining genus, though unknown in Europe, must, from the circumstances in which it is shown to occur, now be acknowledged to be equally a Mesozoic plant. And with regard to the four genera specified, I do not suppose that Dr. Royle will assent to the identification of his *Trizygia* with *Sphænophyllum*, and, if any specimens of the genus *Calamites* had been preserved for description, have little doubt they would have proved to belong to our "non-tuberculated class of opposite sulcated jointed stems," which abound in formations above the true coal-measures. The genera *Poacites* and *Pecopteris* I have found in our Jurassic strata, and a specimen of the latter here is so like one figured by M'Clelland that it is difficult to resist the conviction that they do belong to the same species. If to the evidence now adduced there be added that afforded by the occurrence of the peculiar plants *Vertebraria indica*, *Trizygia speciosa*, &c. at Bardwán and Bhuwán, I think little probability will remain of the Bengal coal-formation being Palæozoïc.

Dr. Hooker, in commenting on the opinion of Dr. M'Clelland, which he supposed to be in favour of the Oölitic age of the Bardwán coal-field,

† "There cannot, however, be a doubt as to its belonging to the true coal formation, from the nature of the coal itself, as well as of the beds with which it is associated."—Secretary of the Calcutta Coal Committee on the coal of the Great Tenasserim River, in Committee's Report, p. 138. Calcutta, 1846.

at the commencement of his first volume, endeavours to prove that no inference can be deduced from the plants discovered in those strata. In his second volume, however, he puts forth an opinion of his own, which, though not formerly enunciated in regard to the Bardwán series of rocks, may be gathered from his remarks on the carbonaceous shales near Pankháwádi. On these shales there were "obscure impressions of Fern-leaves, of *Trizygia* and *Vertebraria*, both fossils characteristic of the Bardwán coal-field, but too imperfect to justify any conclusion as to the relation between these formations.* And then in a footnote it is added, "these traces of fossils" (including a fragment of bone, as well as vegetables) "are not sufficient to identify the formation with that of the Siwálik hills of North-West India; but its contents, together with its strike, dip, and position relatively to the mountains, and its mineralogical character, incline me to suppose it may be similar." It may appear presumptuous in me to impugn the view of one who, from personal no less than hereditary claims, is entitled to the utmost respect on the subject of vegetable remains. I feel, however, that the learned author has been led away by his distrust of the evidence afforded by fragments of plants to rely on the more uncertain indication of mere lithological phenomena. Do strike, dip, &c. furnish us with such strong testimony on the question of age that for their sake the Pankhawádi shales are to be denied a place with the Bardwán beds which have Ferns, *Trizygia*, and *Vertebraria*, and to be ranked with the Siwálik rocks, which, I believe, have none of the three? Or, if the carbonaceous strata at both places are allowed to be contemporaneous, are both to be classed as Miocene or Pliocene when the Bhuwán shales, which like them exhibit "impressions of Fern-leaves, of *Trizygia* and *Vertebraria*," represent sandstones whose numerous fossils, not to mention those of Bardwán itself, are decidedly not more recent than Jurassic?

It only remains to add that the age of the dolomitised limestone cannot be expected to be determined by the evidence of fossils; but as in other localities it is not unfrequently found to alternate with the shale C, it may be set down as nearly coeval with it;—thus making the whole series of rocks from A to D to correspond with the lower members of the great Jurassic formation,— reaching perhaps from about the position of the Scarborough strata downwards into the Lias.

VIII. *Plutonic and Metamorphic Rocks.*—At the end of a paper which has already extended to such a length it would be unbecoming to say

* Himalayan Journals, vol. ii., p. 403.

Age of these Strata.—The coarse iron-banded sandstone above, and the more fissile strata lying conformably below, which are undoubtedly of one and the same era, require first to be considered.* For the sake of clearness, however, I shall refer to the latter member alone, as it has afforded most of the fossils, and furnishes the best data for comparison with the rocks of other localities. Some of the seed-vessels which it has yielded bear no very distant resemblance to those of the Stonesfield slate; *Asterophyllites* (?) *lateralis*, to use the provisional name proposed by Bunbury; and the forms of *Pecopteris* show its near connection with the carbonaceous shales and sandstones of Scarborough; *Phyllotheca*, *Glossopteris*, and the narrow fronds of *Cyclopteris*, if M'Coy's figure † be truly of that genus, mark out the relation to the coal-beds of New South Wales, while *Tæniopteris magnifolia*, and sulcated stems in all respects corresponding with *Phyllotheca*, testify to the agreement with the Virginian carboniferous strata. These coincidences, some of which, as in the so-called *Asterophyllites* (?) and *Tæniopteris magnifolia*, seem to amount even to specific identity, along with the remarkable relations which the distant localities exhibit among themselves, form a network of proof, which, in my opinion, binds down all the various series of rocks to about the same epoch,—an epoch which the known position of the Stonesfield and Scarborough strata shows to be Lower Oölitic.

Whether the Mángali sandstone is to be reckoned contemporaneous with these; whether the two different kinds of strata there—the coarse thick-bedded upper and the fine fissile lower—are to be reckoned the equivalents of our A and B, is a question which observation in the field, and a comparison of the respective fossils, do not enable me to answer. The massive sandstone at Mángali, as has been said, is destitute of iron bands, and the inferior argillo-arenaceous strata are much redder than ours; and especially the organisms of the lower strata at the two places are very dissimilar. Here they are all vegetable, while there they are almost exclusively animal. Only one of the fossil plants at Mángali appears to us to bear a resemblance to anything found in this vicinity. At the same time; if any inference is to be derived from the succession of the rocks there, it is in favour of the idea that they are the counterparts of our A and B. And that they cannot in age be far removed from them is proved by a comparison, not of the Mángali fossils with others in this territory, but of both these with those across the Atlantic. Our

* Professor Oldham states that there is considerable inconformability between those in Kattâk.—S. H.

† Ann. Mag. Nat. Hist., vol. xx., pl. ix., fig. 3.

investigations in the resemblances of the sandstone fossils show that the Nágpur fossiliferous strata are connected with the Richmond carboniferous formation by *Teniopteris magnifolia*, while the Mángali fossiliferous strata are still more closely linked to it by the discovery of what appear to be *Aspidiania*, *Knorria*, and the interesting groups of large and small *Limnadiadæ*. Here, then, we perceive that the lower beds at both of these Indian localities bear a relation to the Virginian coal measures, characterised by an apparent specific identity of fossils; and though the genera of which the species seem to be identical are not the same in both cases, yet it is obvious, from the sort of *ex æquali* argument which we may be permitted to use, that these lower beds must stand pretty closely connected with each other. But I do not wish to push to an extreme reasoning on a point which the progress of investigation here may soon elucidate by finding the strata under consideration in juxtaposition. Meanwhile I consider myself warranted in asserting that our Mángali rocks cannot at all events be older than the Jurassic, if under that term the Lias is also included. Indeed the head of the Labyrinthodont tends to communicate to them a Triassic aspect; but if the Jurassic character of their abundant flora be taken as the real indication of the age of these rocks, we arrive at a conclusion which brings out the interesting fact that the family of Labyrinthodonts, instead of being confined to the Coal and Trias, survived (in the East) until the period of the Lower Oölite.

Regarding the age of our shale c, which there is every reason to believe underlies the coarse and fine sandstones A and B, I have little to say more than that it cannot be much older than these. The occurrence of worm-tracks, as well as of faint traces of *Phyllotheca*, will not allow me to consider it anything but part of the same Jurassic formation.

But, as I have endeavoured to show that the coal-measures of Bardwán are equivalents of our plant-bearing beds, and therefore belong to the Lower Oolitic group, it will be necessary to make a few remarks to establish the correctness of this view. On the age of the coal measures of Bengal two opinions have been submitted to the public within the last four years—one in 1850 by Dr. M'Clelland in his Geological Survey, and the other in the course of the present year by Dr. J. Hooker in his interesting Himalayan Journals.*

[* This portion of the paragraph on the "Age of the Sandstone" has been remodelled since the reading of the paper, so as to introduce the necessary references to the opinions published by Dr. J. D. Hooker in his most interesting work on the Himalayas.—June 14 and September 6, 1854.]

much on this part of our subject. We have in the city of Nágpur, and many localities to the east of it, the usual combination of gneiss and quartz rock, mica and hornblende schist, with massive granite. The peculiarity of the lastmentioned rock in the streets of the capital is that it is generally a pegmatite, consisting of flesh-coloured crystals of felspar with quartz, disposed so as often to take the appearance of graphic granite. But very frequently it occurs with the felspar compact in large white masses, which then have much the appearance of a pure dull porcelain. In Nágpur the most common rock is gneiss, passing into mica schists. The former rock when fresh is quarried, though not extensively, for building, and when disintegrated for the repairing of the roads. But for both of these purposes respectively trap, in the two conditions mentioned, is preferred. Masses of white quartz appear here and there in the city, some with crystals of black schorl, and others with scales of gold-coloured mica. The range of plutonic hills on the west of Kámpti, which is indeed only a narrow prolongation of the great granitic district in the Wein Gangá basin to the east, has been thrown up by an eruption of granite corresponding nearly with the course of the Kolár. The massive rock which lies in the channel of the river, unlike that of Nágpur, is generally grey and very micaceous. Above it, forming the N. base of the range, lies mica schist, passing into granular schistose quartz, which is overlaid by a stratum of dark-grey, glistening, resinous quartz, and then by a considerable thickness of white quartz with scales of mica. This constitutes the ridge of the range for about its entire length from Waregaum to Gumtara, and with its snowy whiteness attracts attention from a great distance. At the northern base of the range, between the quartz and the dolomite of Korhadi, there are interposed some beds of granular quartzose rock which has very much the appearance of being an altered sandstone, in which case it might be the representative in this part of the country of the "Tará sandstone." But throughout the field of crystalline limestone at Korhádi there are many eruptions of granite, which just rise to the surface, without any intermediate metamorphic rocks at all. In some of those instances the granite is garnetiferous, and at its junction with the dolomite the latter, besides its usual ingredients of steatite and tremolite, is intermingled with mica. At Hályádoho, NE. of Umred, mica schist with garnets is quarried for pavements; it abounds along the course of the Amb river. At Segaum various plutonic rocks rise from under the sandstone, and extend northwards to Karsingi. The first, which appears in the north street of Segaum, is syenite, in which the felspar and hornblende greatly

preponderate over the quartz. About 300 yards to the north this is succeeded by another kind of syenite, in which red felspar is combined with a small proportion of quartz, a large quantity of a green mineral (epidote or diallage?). This rock (euphotide?) seems to be massive, and, if we may judge from the fragments of it lying on the surface, is the prevailing rock for some miles. In an adjoining plutonic area a little to the north there is an extensive development of potstone at Jámbul Ghát. The rich dark kind that possesses a dull metallic lustre has hitherto been reserved by Maráthá authority for the manufacture of idols; but the lighter-coloured varieties, which are more common, occurring also at Dini, near Rámpaili, and at Biroli, on the Wein Gangá, near Tharorá, have been long used for fashioning into vessels. Steatitic schists of a pure white tint, with a few imbedded garnet crystals, occur at Kaneri, on the Chulband river, and at various other localities east of the Wein Gangá. In many parts of this river's course, and in the Lánji hills, hornblende rocks, both schistose and massive, abound. A coarse kind of corundum occurs at Pohorá, in the pargannáof Sáhangadi, on the south of the road from Núgpur to Ráyepur.

Metals.—Small quantities of gold are found near Lánji in the sands of the Son river, a tributary of the Wein Gangá. In some fragments of quartz rock on Nimá Hill, west of the Pech river, Colonel Jenkins found galena. Where this rock is associated with dolomite, as at Kumári, it contains manganese. But the principal ore which it yields is iron; this may be obtained in immense quantities in the province of Chándá, both on the east and west of the Wein Gangá. Near Dewalgaum, only three miles from the east bank of this navigable stream, which communicates by the Godávari with the Bay of Bengal, in the midst of a level country covered with jungle, there is a hill named Khandeshwar, consisting of strata tilted up at an angle of 60° or 70°, the dip being to the north. The summit of the hill is about 250 feet above the level of the plain, 100 feet being gradual ascent through jungle, and the remainder an abrupt wall of naked rock. The iron ore is for the most part specular, though many specimens possess polarity, and seem to be magnetic. It is on the surface of the slope that it is most valuable; but the whole mass, from an unknown depth under ground to the highest peak above it, is richly laden with metal. This single hill might furnish iron for the construction of all the railroads that shall ever be made in India, and with its abundance of fuel and cheapness of labour, and convenience of situation, it is admirably adapted for an export trade to every part of the country. But besides this locality, there are

others in the neighbourhood which could each contribute an unlimited supply of the same indispensable metal. Among these may be mentioned Lohárá, Ogalpet, and Metápár, Bhánúpur, Monda, and Gunjáwahi, which are all on the W. of the Wein Gangá; and at all of which places the ore seems to occur in quartz, and is sometimes granular, but for the most part compact. Unimportant crystals of it are scattered through the pegmatite of the capital. Notwithstanding that the specular ore is so abundant, there are many districts on the north of those already named where the hydrous oxide, in the shape of the heavier lumps of laterite, are selected for smelting by the poor natives, whose tools are anything but adapted for contending with the hard masses of the metamorphic matrix or gangue.

Age of the Plutonic and Metamorphic Rocks.—These evidently do not all belong to one and the same epoch. Colonel Jenkins observes that at Nayakund, on the Pech, to the north of Nágpur, he met with "a grey granite, composed chiefly of whitish felspar in very large crystals," a mass of which "was distinctly traversed three or four times by granite veins, accompanied by as many heaves." The granite of the veins was smaller-grained and redder the more recent it was, and, to the best of that officer's recollection, was destitute of mica. Without, however, more extensive artificial sections of the rocks in this neighbourhood than have ever been executed, I fear it will be difficult to fix the respective ages of the different eruptions. A cursory view of the question would lead to the supposition that the micaceous granite is more ancient than the pegmatite; but, in areas where both are presented in the vicinity of each other, the soundness of this view may be questioned, or at all events it appears to be impossible, in the present state of the country, to have it confirmed. The pegmatite of Nágpur city, which we have said is associated with gneiss, mica schist, and quartz with mica and with schorl, is evidently a very recent eruption, for it has not only converted much of the very highest member of the Jurassic sandstone into gneiss, but it has completely upheaved it. That the eruption, therefore, was posterior to that formation, there cannot be the slightest doubt. But it has sometimes occurred to me, though the observations of the most eminent Indian geologists are opposed to the thought, that this pegmatitic outburst may be subsequent even to our trap.

The section (Pl. VI., fig. 2) may throw some light on this doubtful point. In this section we have the overlying trap (*a*) occupying the two summits of Sitábaldi Hill, under it the tertiary freshwater formation (*b*) and the intruded amygdaloidal trap (*c*) which has encroached on it.

At the foot of the hill is the upper sandstone (*d*), which has been metamorphosed to a great extent by the gneiss (*e*), or rather by the pegmatite (*f*) beneath. On the north part of the hill the gneiss comes to the surface; but a little further north it is, together with the sandstone, overlaid by trap. This trap, which agrees with that overlying the tertiary beds in being nodular and poor in minerals, resembles in the very same respects the amygdaloid where it constitutes the superficial rock on the ascent. Proceeding in the same line, we find the trap cease and the sandstone upheaved. After this interruption the trap is again seen to be on the surface. Now the question arises: what is the reason that the trap is not found where the granite has thrown up the sandstone? The most obvious reply is that once it was there, as it is seen on either side, but that by this eruption it was removed; in which case the plutonic rock would be of more recent origin than the volcanic. But, as there is the alternative of the latter never having been spread over the position of the former, and as this alternative is favoured by the examination of other localities, I content myself with merely submitting the case for determination, and stating that my latest observations lead me to believe that the trap is of later age than the granite. At all events the section undoubtedly shows that the pegmatite and some of its accompanying gneiss are of an age subsequent to the upper sandstone. And yet in a layer of conglomerate contained in the red shale of Korhádi we meet with pebbles of undulated mica schist very like that which occurs in the present day between Suradi and Korhádi. Rocks of this character, then, whether we are right or wrong in suggesting their connection with any still existing, did exist before the deposition of the red shales.

Conclusion.—In tracing the geological history of this district from the facts that have been brought forward, we are made to feel that the early epochs are involved in the utmost obscurity. While in many other countries the records of what took place in Palæozoïc times have been preserved in successive strata of the earth's crust, in the Dakhan they have been wholly obliterated. It is not until we come down to the Jurassic era that we meet with archives whose characters can be read. Then we find that Central India was covered by a large body of fresh water, which stretched southward into the Peninsula, and eastward into Bengal, while on the north and west it communicated by some narrow channel with the sea. On the shore of this lake earthworms crawled, and small reptiles (frogs) crept over the soft mud. In its pools sported flocks of little Entomostracans resembling the modern

Estheria, mingled with which were Ganoid fishes and Labyrinthodonts. The streams which fed it brought down into its bed the *débris* of the plutonic and metamorphic rocks which then constituted the greater part of the dry land, and which were covered with an abundant vegetation of Ferns, most of them distinguished by the entireness of their fronds. Low-growing plants with grooved and jointed stems inhabited the marshes; and Conifers and other Dicotyledonous trees, with Palms, raised their heads aloft. Meanwhile plutonic action was going on, and strata, as they were formed, were shattered and reconstructed into a breccia; and finally an extensive outburst of granite elevated the bed of the lake and left it dry land. The sea now flowed at Pondicherry and Trichinopoly, depositing the cretaceous strata which are found there.

At the end of this epoch Central India suffered a depression, and was again covered by a vast lake, communicating with the sea, not towards Cutch as before, but in the neighbourhood of Rájámandri, to which the salt water had now advanced. When the lake had, during its appointed time, furnished an abode to its peculiar living creatures and plants, it was invaded by an immense outpouring of trap, which filled up its bed, and left Western and a great part of Central India a dreary waste of lava. But these basaltic steppes were ere long broken up. A second eruption of trap, not now coming to the surface, but forcing a passage for itself under the newer lacustrine strata, lifted up the superincumbent mass in ranges of flat-topped hills. Since then, to the east, water has wept over the plutonic and sandstone rocks, and laid down quantities of transported materials impregnated with iron, and some time after there was deposited in the west a conglomerate, imbedding bones of huge mammals, and above it a stratum of brown clay, which immediately preceded the superficial deposits of the black and red soils.

P.S.—I have to acknowledge my great obligations to Lieutenant Colonel Alcock, of the Madras Artillery, and Dr. Leith and Mr. Carter, of Bombay, for assisting me in obtaining access to books (or extracts from them), of which I should otherwise have been deprived.

The map of the district described is coloured geologically from an excellent political map given in Rushton's Bengal and Agra Gazetteer for 1842. The formations between Chindwárá and the Mahádowa Hills are laid down from a sketch obligingly furnished to me by Mr. Sankey.

Description of the Cranium of a Labyrinthodont Reptile, Brachyops Laticeps, from Mángali, Central India. By Professor Owen, F.R.S. F.G.S. [With a Plate.]*

[Read June 21, 1854.]

The fossil obtained by the Rev. Messrs. Hislop and Hunter from the sandstone series of Mángali, about sixty miles to the south of Nágpur, and transmitted for my examination, is a considerable portion of a skull, wanting chiefly the tympanic pedicles and the lower jaw; it is imbedded in a block of bright brick-red compact stone, with its upper surface exposed. The skull (Pl. XII.) is broad, depressed, of an almost equilateral triangular form; the occipital border or plain rather exceeding in extent each lateral border, which borders converge with a slight convex curve to the rounded obtuse muzzle. The breadth of the occiput is 4 inches 9 lines, and the extent of each lateral border of the skull in a right line is 4 inches 6 lines. Most of the cranial bones are impressed by rather coarse grooves, radiating in each from a prominence which indicates the primitive centre of ossification, the intervening ridges being in some parts broken up by communicating grooves into tubercles. The orbits (*o*, *o*) are entire, of a moderate size, of a full oval form, and situated in the anterior half of the skull. The middle line of the upper surface of the skull is slightly depressed; at the upper and fore part of the skull on each side there is a smooth continuous groove of a sigmoid form, with a strong curve convex outwards anterior to the orbit, and with a less strong curve convex inwards on the inner side of the orbit: between the orbit and the occiput there is on each side a shorter groove, extending from the exoccipital forwards and a little outwards to the postfrontal, where it bends more directly outward and downwards behind the orbits: these grooves probably lodged large mucous canals. Portions of small, conical, pointed, subequal teeth extend in a single series along the alveolar border of the upper jaw (fig. 2, [21]), from the muzzle along the lateral borders of the fossil, to two-thirds of an inch behind the orbits. At the bases of some of these teeth may be discerned indentations converging from the periphery towards the centre of the dentine.

The entire orbits, closed below by a backward extension of the superior maxillary [21], and the connection of this bone by a malar [26] and squamosal [27] with the mastoid [8] and tympanic [28], forming a complete zygoma, prove that the fossil did not belong to the class of fishes;

* Reprinted from the Quarterly Journal of the Geological Society of London, vol. xi., part i, p. 37.—February 1855.—H. J. C.

whilst the strong points of resemblance which the skull presented to the *Labyrinthodonts*—in its broad and very depressed figure (especially the great breadth of the occiput), in its external sculpturing (specially the number and position of the mucous grooves), in the form and position of the orbits, and in the characters of the teeth—led me to investigate the structure of the deeper part of the occiput, which was concealed in the matrix, for the more decisive character which that part of the cranium affords of the batrachian affinities of the singular reptiles to which the Mángali skull seemed, by its more obvious characters, to be most closely allied.

I was gratified by finding that the occipital bone (which, like the rest of the skull, was distinguished from the red matrix by its yellow colour) terminated posteriorly in two well-defined subdepressed convex condyles [22] not so close together as in the great *Labyrinthodon salamandroides* (*Mastodonsaurus* of Jaeger), but separated as in the *Trematosaurus* of Burmeister.* A part of the broad atlas (*a*) was found in connection with these condyles.

The superoccipital region is formed by a pair of bones, *s*, *s*, each with a slightly prominent centre at the angle between the horizontal and backwardly-sloping part of the occiput: they may represent a divided superoccipital bone, but I cannot trace a suture separating them from the exoccipitals supporting the condyles, where it is represented by Burmeister in the *Trematosaurus*.

External to these is a large bone with a well-marked prominent centre, from which the grooves of the outer surface radiate: on the left side a part of the tympanic remains in connection with this bone, which I regard as the mastoid [8], which bone occupies a similar position in the *Labyrinthodonts*. The parietal bones [7, 7] continue the cranial walls in advance of the superoccipitals, and show a small oval vacuity in their median suture—the "foramen parietale," as in the *Trematosaurus*; the foramen is situated near the hinder part of the suture; an accessory parietal [7*] extends outwards from the hinder part of the main body of the bone on each side, to the angle between the superoccipital and mastoid. Traces of a suture seem to show this to be a dismemberment of the parietal: it occupies the place of the bone marked *n*, and called "os temporale squamosum," in the above-cited figure of the *Trematosaurus*; but the true squamosal is always anterior and external to the mastoid in the reptiles in which it is unequivocally present; and it is restricted to its zygomatic place and functions, not

* Die Labyrinthodonten, 4to, 1840, part i. pl. 1.

becoming a proper cranial bone until the mammalian type is reached. The precise boundaries of the frontal [7] and the sutures dividing it from the nasals and prefrontals cannot be traced, the skull being abraded at this part. The postfrontals [12] have their centre as well marked and prominent as in the mastoids, and extend to those bones from the outer and back parts of the orbits. Traces of the malar [26] and true squamosal [27] may be discerned on the left side, extending from the slender maxillary beneath the "postfrontal" to the tympanic [28], beneath the mastoid [8]. The bone here called "postfrontal" is the "os orbitale posterius" (*i*) of Burmeister, and the name "os frontale posterius" is restricted in the abovecited figure of the *Trematosaurus* to a supplementary bone which is interposed in that Labyrinthodont, as in the present, between the bone marked [12], the parietal [7], and frontal [0] where it forms the inner half of the back part of the orbit. This bone appears to me to be a dismembermont of an unusually developed postfrontal, and both it and the supernumerary bone [7*] are remarkable departures from the normal cranial structure, characteristic of some, if not of all, of the Labyrinthodont batrachians. The marked departure in the form and proportions of the present cranium from those of the equally well-preserved specimens of European Labyrinthodonts leads me to the conclusion that the Mángali species indicates a distinct subgenus in that group of reptiles, and I propose to designate the species so represented by the term '*Brachyops* laticeps*,' indicative of its peculiar proportions.

Although the abraded and otherwise mutilated state of the skull of the *Brachyops* is such as to prevent my giving a more extended anatomical description of it, and determining more precisely and satisfactorily the boundaries and homologies of the constituent bones, it nevertheless permits so many characters of the skull of the Labyrinthodont Batrachia to be determined as can leave no reasonable doubt of its true nature and affinities; and thus the results chiefly required by the geologist, in reference to the probable age of the stratum in which this fossil is imbedded, may have been attained.†

DESCRIPTION OF PLATE XII.

Fig. 1. Upper view of the skull of the *Brachyops*, nat. size.
2. Side view of the same, nat. size.

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* From $\beta\rho\alpha\chi\grave{\upsilon}s$, *short*; $\grave{\omega}\psi$, *face*; in reference to the shortness of the facial part of the skull anterior to the orbit.

† When a family of animals is of considerable extent, it becomes necessary to indicate to what division of it a particular genus belongs. This is doubly requisite if a question of geological age depends on the determination of the point. Such happens to be the case in regard to the *Brachyops* described above by our great comparative anatomist. It is well

Fig 1

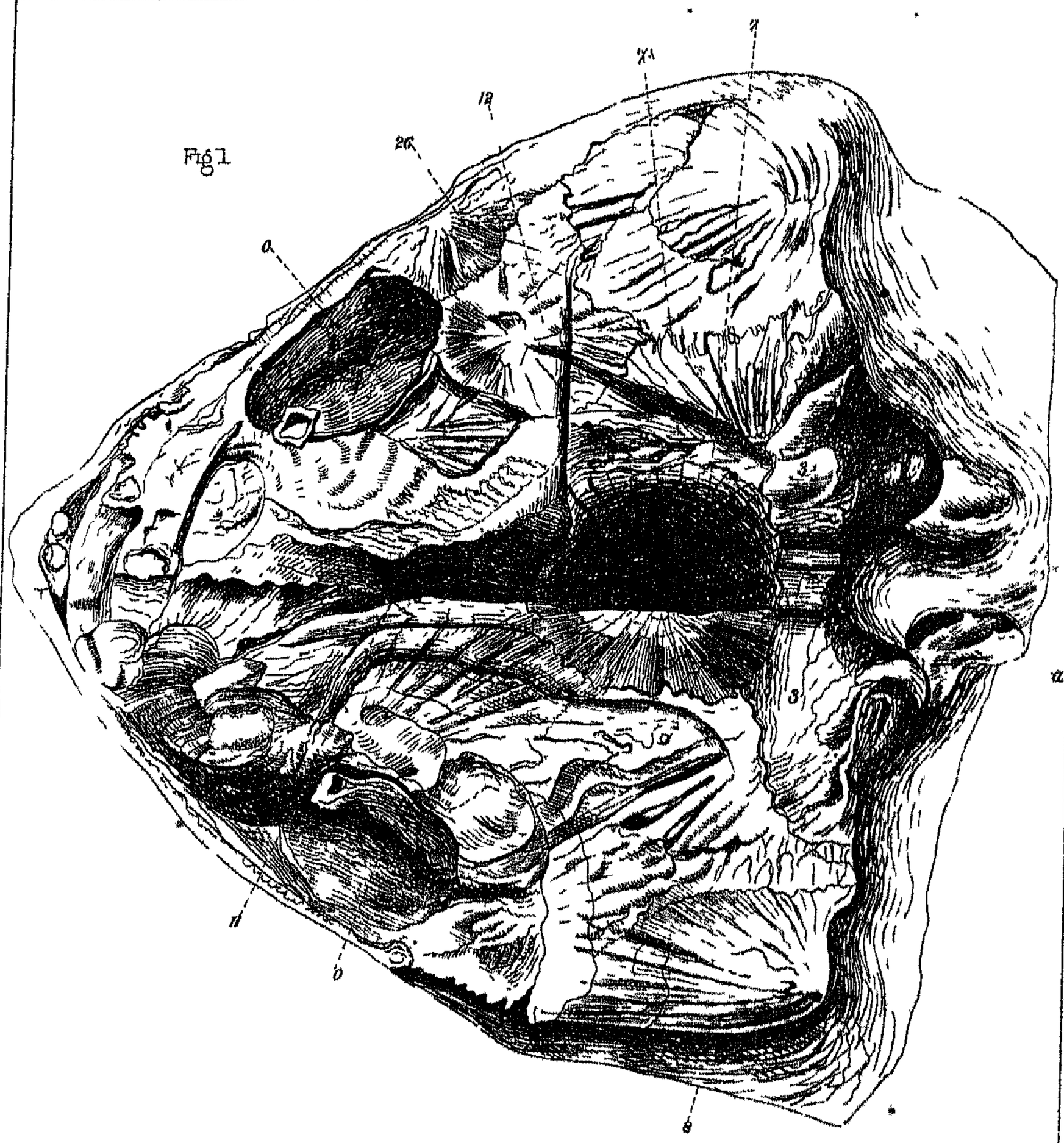
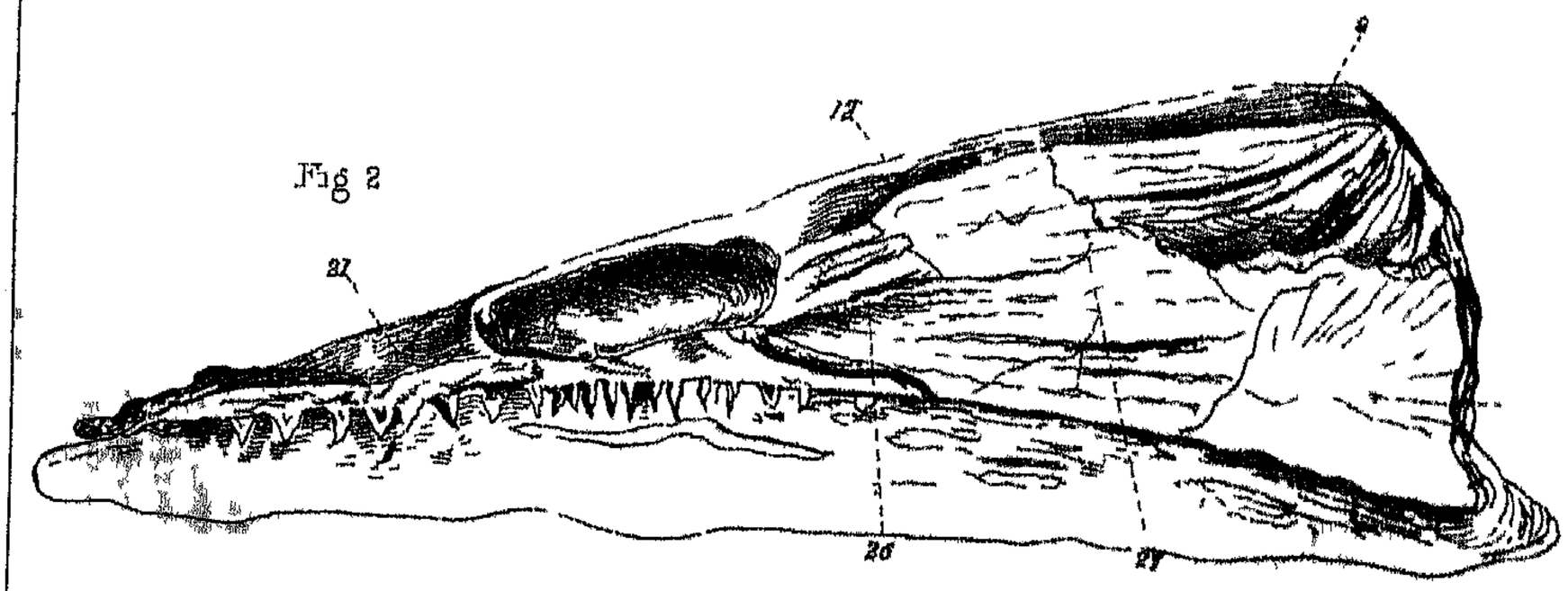


Fig 2



BRACHYOPS LATICEPS (Owen); from Mangali Central India

H. Rozario

B.N.S.P


IMPERIAL

On the Connection of the Umrct Coal-beds with the Plant-beds of Nágpur, and of both with those of Burdwan. By the Rev. S. Hislop.*

[Read June 13, 1855.]

In the observations on the Jurassic formation of the Nágpur territory, which I had the honour to submit to your Society, I showed that it consisted of four members in the following descending order† : A, thick-bedded coarse ferruginous sandstone, with a few stems of trees; B, laminated sandstone, exceedingly rich in vegetable remains: C, clay-shales, of various colours, in which are found the traces of reptiles and worms; and D, limestone, which within our area is generally crystallised from its contact with plutonic rocks. At the time of penning these remarks, not having had an opportunity of inspecting any of our Indian coal-measures, I was inclined to regard them as the equivalents of our argillaceous strata marked C; but having recently enjoyed this privilege, while out on a Mission tour with my friend the Rev. R. Hunter, I propose to communicate the modifications which have in consequence been wrought on previously-formed views.

Our tour extended about 120 miles NNW. of the city of Nágpur,—a distance which carried us past the carbonaceous strata near Umrct, as far as the bituminous shales at the south base of the Pachmadi or Mahádewa Hills. These localities had both been visited by Dr. Jerdon and Lieutenant Sankey in 1852, and the results of their investigations have been laid before your Society.‡

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known that *Labyrinthodontidæ* have been found in more than one formation. The British remains of this family, which were formerly supposed to be Triassic and therefore Mesozoic, are now, in consequence of more accurate observation of the strata, assigned to the Permian formation or Palæozoic epoch. But there are still, in the Keuper of Germany, genera whose claim to be regarded as Mesozoic has not yet been disputed. Among these there is one, named by Von Meyer *Metopias*, which he includes in his sub-family of *Prosthophthalmi*, from its having the orbit of the eye situated nearer the muzzle than the neck. Now the *Brachyops* is remarkable for this peculiarity, and therefore ought to be classed under the *Prosthophthalmi* of the Keuper, and not with the Permian Labyrinthodonts, whose eyes are placed either in the middle of the *semicranium* or behind it. These observations, which in substance I communicated to the London Geological Society, along with the specimen which suggested them, have not been referred to by Professor Owen, but I call attention to them here, as I shall have occasion to make use of them in a subsequent note, when I come to sum up the arguments which in my opinion tend to prove the Jurassic age of the Mángali and associated rocks.—*Note by the Rev. S. Hislop, August* 1856.

* Reprinted from the Quarterly Journal of the Geological Society of London, vol. xi., part i, p. 555, November 1855.—H. J. C. † Vide this vol., p. 273.—H. J. C.

‡ Quart. Journ. Geol. Soc., vol. x., p 55

The coal-field of Umret is about five miles north of the village, near a small hamlet dignified with the name of Bari, or Great, Barkoi, to distinguish it from Chhoti, or Little, Barkoi, which lies three-quarters of a mile to the south. Leaving Umret the traveller passes over granite for about a mile, when he begins to ascend trap-hills, which continue, with only a slight reappearance of plutonic rock in the low ground near Tawari, until within three-quarters of a mile of Chhoti Barkoi, where they end in an abrupt descent, at the foot of which there emerge beds of sandstone, that constitute the surface rock to the rivulet at Bari Barkoi. This stream has cut a passage through the sandstone, and laid bare the dark-coloured strata underneath, which are seen to dip at an angle of 5° to the WSW., the direction in which the water flows. The exposure displays the following succession: overlying sandstone, about 50 feet thick; coal, 1½ or 2 feet; argillaceous shale, 3 feet; bituminous shale, 1 foot; arenaceous and micaceous shale, 3 feet; and white sandstone, depth unknown.

On observing the strata and the order in which they occurred, I remarked to Mr. Hunter that the shale would probably turn out to be the representative of the fissile sandstone, abounding in fossils, that is so well developed at Kámpti, Silowádá, Bhokárá, Bharatwádá, &c. In hazarding this conjecture I took it for granted that the overlying rock was the common sandstone of this country, which is for the most part traversed by iron bands. Search having been made, the iron bands though not of the typical character, were discovered. So far the hypothesis was confirmed.

Additional light was thrown on it by examining the circumstances under which the argillaceous and bituminous shales are met with at the Mahádewas. The sandstone forming the mass of that mountain range must be about 2,000 feet thick, and presents a line of bold mural crags extending E. and W. for upwards of twenty-five miles. The front of the precipice is towards the south, while the strata dip at an angle of 5° to the north, or, more correctly, NNE. However much the thickness of these arenaceous beds exceeds that of the ferruginous sandstone in the immediate neighbourhood of Nágpur, there can be no doubt that both rocks are the same, as both possess the same iron bands, which I consider positive evidence of identity, when they do occur, though their absence may not be conclusive as to dissimilarity. Under the sandstone there are about eight feet of green shales, becoming more micaceous and laminated below, and succeeded for about three feet by bituminous shale, which disappears under the surface of the ground. Unlike

Barkoi, there is no seam of coal to be seen, but the tendency to it in the bituminous shale is manifest enough; and, indeed, this latter bed, as I shall endeavour to show when I come to speak of the organic remains, is palæontologically a part of our Indian carboniferous strata.

Here, then, at Barkoi and the Mahádewas, as well as near Nágpur, we have the same thick-bedded iron-banded sandstone overlying in the last-mentioned locality more fissile strata of a somewhat similar material, but at the former two places superposed on argillaceous and carbonaceous or bituminous shales. Are then the *lower* beds also of the same age in all three localities? Of the contemporaneity of the inferior strata at Barkoi and the Mahádewas there cannot be two opinions; but as those in our immediate neighbourhood differ in colour, and to a considerable extent in composition, some hesitation may be felt in including them in the identification. It may be supposed that there is a deficiency in the one district which is supplied in the other.

Now it may help to remove doubt to mention that even in this vicinity (Nágpur), where the lower strata are generally of a whitish hue, they present in their higher portion a certain quantity of clay, which becomes less and less as we descend, until at last, as in the underlying beds at Barkoi, we arrive at pure sand. And, to complete the analogy in regard to composition, it may be added that in a particular spot at Bhokárá, six miles N. of Nágpur, the higher laminæ now referred to exhibit not only the argillaceous mixture, but an approximation to the carbonaceous colour, being quite brown through the amount of comminuted vegetable matter which they contain.

But for direct proof of identity in age an appeal must be made to the fossil contents of the strata under comparison. At Barkoi we found the following genera: *Glossopteris* and *Cyclopteris* with *Phyllotheca*, *Vertebraria*, and other stems, and a variety of fruits or seeds. At the Mahádewas, during the very hurried visit which we made to that locality, we discovered *Glossopteris*, *Phyllotheca*, *Vertebraria*, and fruits or seeds; besides which, I believe, our friend Mr. Sankey had previously brought to light specimens of *Pecopteris*, *Sphenopteris*, and *Trizygia*.

In regard to the Barkoi plants, I think there is scarcely one that cannot be specifically matched with some one from the laminated argillaceous sandstone in the vicinity of Nágpur. Of the genus *Glossopteris* the bituminous shale furnished several species; but among them there is not one that strikes me as not having been observed before in our arenaceous strata. The *Cyclopteris* of Barkoi exactly agrees with that

of Bharatwádá, both being oblong-cuneate, and characterised by the same venation. The most abundant *Phyllotheca* at Barkoi is one with ten sulci, which is also the one most frequently discovered near Nágpur. Of *Vertebraria* there does not appear to be more than a single species, though Royle* has found a *V. radiata* from a transverse section of the stem of his *V. Indica*, and M'Coy† has added another species, *V. Australis*, from New South Wales, because there is a slight difference in the radiations of his transverse section from those of Royle's.

Taking the *Vertebraria* found at Barkoi as belonging to the only species hitherto discovered either in India or Australia, it is satisfactory to ascertain that it is just as abundant in all the localities of our sandstone as in the coal-formation of Barkoi. Besides the *Vertebraria* there is another stem common at Barkoi which has its exact counterpart nearer Nágpur. It is undescribed, but may be distinguished by its nearly opposite leaf-scars, and occurs plentifully in the laminated sandstone of Silowádá. The fruits or seeds from Barkoi I have not at present the means of comparing with those of Kámpti. One of them, however, may be easily recognised as identical with a fruit or seed lately met with at Bharatwádá.

Between the vegetable remains of the Mahádewas and those of our laminated sandstone a like comparison might be instituted. If, for example, Mr. Sankey's *Pecopteris* from that locality agreed, as my memory suggests, with one figured by M'Clelland,‡ then it must have corresponded with one that occurs at Kámpti. The *Vertebraria*, both

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* Illustrations of the Botany &c. of the Himalayan Mountains. When I formerly referred (Journ. No. 43, p. 371, &c, and MS. account of the fossil plants) to this remarkable genus of plants, I had not in my possession a specimen from the Indian coal-shales. The recent examination of many such has served to increase in my mind the conviction that its character has been misunderstood. Its smaller branches are somewhat slender and apparently winged. Sometimes they are found lying along the plane of the laminæ,—at other times running across it. When a branch is discovered in the former situation, it is found to be split in two halves, with the wings that lie in conformity with the lamination stretched at their full breadth, while those that lie at an angle with it are, as it were, fore-shortened. In this case there is no trace of radiation. But when a branch is found running across the laminæ as often happens, all the wings have equal room to retain their form, and hence the radiated appearance. The number of the radii or wings differs in specimens which I have examined from the same locality, and, as I believe, in portions of the same plant. A similar want of uniformity in this respect is perceptible in the specimens figured by Royle. That there is any such thing as dichotomous-veined foliage between the radii does not appear from the shale specimens that have fallen under my notice. On the contrary, they seem to be wholly destitute of leaves. But there is every reason to think that our sandstone specimens possess these appendages, and that they are of a narrow linear shape, like those of the *Phyllotheca*.

† Ann. and Mag. Nat. Hist., vol. xx., p. 147.

‡ Report of Geological Survey for 1848-49.

at the Máhadowas and near Núgpur, might be proved to be identical, and a general resemblance pointed out in regard to *Glossopteris*, *Phyllotheca*, and the fruits or seeds. But after the statements of the previous paragraph it is scarcely necessary to enlarge.

From the above numerous coincidences it may be inferred that our laminated sandstone is the equivalent of the carbonaceous and bituminous shales in the north of this territory. It follows, as a matter of course, that the position of the coal-measures is among the beds immediately underneath the ferruginous sandstone (A).

If we look beyond this province we shall find this view amply confirmed. The account given by Dr. Walker* of the discovery of fragments of coal at Kotá, in the Nizam's dominions, would lead to the belief that the carbonaceous and bituminous shales which he noticed were above the highest bed of argillaceous limestone. But whether this may have been the case or not is of little consequence, as all I contend for is that they are near the base of the iron-banded sandstone —a position which must at once be assigned them when we take into account their relation to the surrounding hills at Kotá.† The succession at Duntimnapilly,‡ according to the same writer, seems to have been,—anthracite, carbonaceous sandstone, and micaceous sandstone. What the rock, 15 feet thick, above the anthracite was, he does not mention. But it is worthy of remark that the carbonaceous and micaceous sandstone, into which the anthracite passes downwards, bear a great resemblance to the strata underlying the coal-seam at Barkoi, and appear to coincide with the eight feet of laminated sandstone mentioned by the late Dr. T. L. Bell in his detailed description of the rocks bored through at Kotá. It is to this lamented officer that we owe the best materials for comparing the coal-measures on the banks of the Pranhítá with those in the north of Núgpur. The section with which he has furnished us is—sandstone (iron-banded), from 50 to 500 feet; argillaceous limestone, 9 feet; bituminous shale, three-quarters of an inch; then argillaceous limestone, bituminous shale, and limestone again, which passes into the laminated sandstone alluded to above. Without quoting further from this list of strata, which has already been published in the Journal§ of the Society, I may mention that the *bituminous* shale at Kotá, though to a considerable extent interstratified with

* Bom. Asiat. Soc. Journ., vol. x., p. 312.

† Quart. Journ. Geol. Soc., vol. x., p. 374, and note.

‡ Beng. Asiat. Soc. Journ., vol. x., p. 344.

§ Quart. Journ. Geol. Soc., vol. viii., p. 231; vol. ix., p. 351; and vol. x, p. 371.

argillaceous limestone, &c., is found only in the upper half, while *argillaceous* shales and limestone preponderate in the lower half. Limestone, according to the most recent information received from Dr. Bell, was the lowest rock reached after passing through 27 feet of red clay-shale.

Again, at Palamow, the first beds that Mr. Homfray* came upon under a mass of sandstone 150 to 200 feet thick were shale and coal, resting upon 30 feet of sandstone, in which we may again trace a similarity to the coal-field at Barkoi. Such also is the order of the strata at Singra, as given by Mr. Homfray. Mr. Carter, in his admirable "Summary of the Geology of India,"† shows that Jacquemont found small layers of anthracite between the strata of compact limestone which immediately underlie the Pannâ sandstone. According to Franklin,‡ in all the glens connected with the Pannâ range, particularly in that of the Bagin river, black bituminous shale crops out from beneath the sandstone. Mr. Osborne's observations§ prove that under the sandstone of Umla Ghât there is shale with exudations of petroleum, which is succeeded below by alternate beds of sandstone and shale, limestone lying under all.

Thus we see that south and north-east of this territory, as well as within its limits, the carbonaceous and bituminous shales may be said immediately to underlie the ferruginous sandstone. It is difficult to comprehend the Burdwan coal-field in our comparison, for it seems to lie in a basin, and the carboniferous strata rise to the surface without any superincumbent sandstone. But the connection, which cannot be established lithologically, may be rendered very manifest by the evidence of fossils. Species of *Trizygia*, *Vertebraria*, *Glossopteris*, and *Pecopteris* are common to the shales of Bardwán and those of the Mahádewas. And, although Dr. M'Clelland has professedly figured no *Phyllotheca*, or Calamite as he would name it, from Bengal, yet there can be little doubt that what he calls *Poacites minor*‖ is identical, wanting the joint, with one of our Phyllothecas found both at the Mahádewas and Kampti, and specifically distinguished by the possession of eight sulci.

I am not certain, though I am disposed to think, that the *Poacites muricata*¶ of the same author is the unfurrowed stem, with nearly

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* Beng. Asiat. Soc. Journ., vol. x., p. 374.

† Bomb. Br. Royal Asiat. Soc. Journ, No. 19, p. 204.

‡ Asiat. Res., vol. xviii, part. i., p 103.

§ Beng. Asiat. Soc. Journ., vol. vii, p. 848.

‖ Geol. Survey, tab. xvii., fig. 4, with the description at p. 55.

¶ Geol. Survey, tab. xiv, fig. 6.

opposite leaf-scars, described above, p. 295, as common in the shale of Barkoi, and the laminated sandstone of Silowídá. The breadth and rigid appearance of our specimen are exactly the same as in M'Clelland's figure, and there is occasionally on them a fine longitudinal striation, which might be taken for the venation of an endogenous leaf.

Subjoined is the succession, from above, of our Indian freshwater† oölitic formation, according to the view taken in this paper.

I. *Upper Sandstone Series; called by Mr. Carter the "Panná [Punna] Sandstone."*

In general, coarse and thick-bedded, sometimes friable, and white, variegated with red blotches; at other times hard and of rusty colour, traversed by iron bands. Contains a few stems of trees about the base. Thickness at Nágpur 25 feet; at the Mahádowa hills upwards of 2,000 feet.

II. *Laminated Series; the same as Mr. Carter's "Kattrá Shales."*

1. Either arenaceous, carbonaceous, or bituminous. The arenaceous strata more or less mixed with clay and mica; laminated and abounding in fossils above, and gradually becoming coarser, thicker-bedded, and more destitute of organic remains below. The carbonaceous or bituminous shales are the equivalents of the laminated fossiliferous sandstone just mentioned. Though occasionally alternating with argillaceous limestone, they for the most part pass into micaceous or coarse sandstone. Thickness from 300 feet in the Nágpur territory to 2,000 feet in Bengal.

2. Argillaceous shales, green, red, blue, and more rarely white, in some localities alternating with argillaceous limestone. Contains the traces of reptiles and worms. Thickness about Nágpur 80 feet, though much greater in the Bandárá district, to the east.

3. Limestone, sometimes compact, but often crystalline, and dolomitic. Near Nágpur 100 feet, at Mudalaity 310 feet thick.

From the above arrangement of the laminated series it will be seen there is a difficulty in disposing of the limestone. Beds of it in some districts of India alternate with our No. 2, and even with No. 1. At Mudalaity, where the latter appears to be wanting, the whole mass of it is said to overlie the argillaceous shales. I have followed the order as it is within this territory, where the limestone is most frequently crystalline, while the red shale, lying above it, has suffered no change from heat. This I am disposed to consider the typical order of succession among our "Freshwater Oölites." At Kotá, though the calcareous and

bituminous beds are interstratified to a certain extent, yet the greater part of the latter are found above, and of the former below. Newbold, who gives us the superposition at Mudalaity, embodies his views of the order of stratification throughout Southern India in these words :—"The limestone occupies, with few exceptions, the lowest position in the sections afforded by the great lines of drainage of these tracts, and in places where the superincumbent strata have been stripped off. Next in order of superposition come calcareous shales, mingled with much argillaceous matter, then argillaceous shales and slates, sandstone, siliceous and arenaceous schists, quartzose rock, and sandstone conglomerate."* In some parts of Bundlekhand the limestone occupies a high position : but, as we have had occasion to notice before, at Bagin the bituminous shale lies above the greater part of it. In the coal-fields of Bengal calcareous strata appear to be wholly wanting.

To complete the catalogue of our Indian† Jurassic Formation, I might here add—

III. *Lower Sandstone Series.*

This is developed at Mudalaity and in Bundlekhand, and has received from Mr. Carter the name of the "Tárá sandstone;" but as it does not occur within our area, except perhaps in the form of gneiss, mica schist, and other metamorphic rocks, underlying our crystallised limestone, I forbear to enter on the consideration of it at present.

* Roy. Asiat. Soc. Jour., vol. viii., p. 160.

† In the beginning of 1853, when I first published my sentiments on the sandstone and associated strata of Nágpur, I was under the impression that they were all related conformably to each other; and hence, though I made a distinction between the thick-bedded sandstone above and the plant-bearing argillaceous sandstone beneath, and again between the latter and the underlying shales, and though I showed that plutonic agency had been at work in the intervals between some of these, yet it did not occur to me to doubt that both the highest and the lowest were of the same general age as the intermediate strata. I have since learned, from Mr. A. Schlagintweit, that the sandstone and inferior shales of Southern India are unconformable; and more recently I have been informed by Professor Oldham that there is a considerable difference in inclination among the rocks of the Katták coal-field, and especially between those corresponding to our upper sandstone and our argillaceous and carbonaceous beds. As this information could scarcely have been elicited from the appearances presented by the rocks of Central India, it is with gratitude that I hail the light arising from other quarters. But it now becomes a duty to inquire how far this discovery modifies the arrangement proposed for our strata three years ago. To me it appears its effect is not great.

It is to be borne in mind that the period when the rocks under consideration were deposited was just the period when plutonic action was most frequent. If granite disturbed our plant-beds before the deposition on them of the upper sandstone, we know that it also intruded on the latter strata, showing that they were in existence before plutonic agency had spent its force, and that probably the interval which elapsed between the two eruptions was not so great as to admit of a change of formation.

But there is evidence perhaps more direct. Our upper sandstone is unquestionably the same as that which is found on the banks of the Pranhitá and Godávari. Now it was in the conglomerate or highest part of this sandstone that the late Dr. T. L. Bell discovered his reptilian remains, which Professor Owen believed to agree best with the structure of the Teleosaurus and Amphicœlian Crocodiles,—animals which generally occur in the Jurassic formation.

With regard to the age of the underlying fossiliferous rocks, I adhere to the view which I have always entertained, since I discovered in them the first of our large assortment of ancient organisms. True, the majority of these are vegetable remains; but I see not why their evidence on that account is to be slighted, provided the specimens are entire and present the parts on which a correct classification may be founded. Are not plants characteristic of climate in their distribution over the earth's surface, as well as animals? And are not the former characteristic of eras in their range through the earth's crust, as well as the latter? I admit that the ancient Flora has lost many characters which aid in the classification of existing species; but so has the *ancient Fauna*. I acknowledge, in reference to Ferns, whose essential parts are perhaps best capable of preservation, that some genera have existed through many geological changes; but the same objection may be brought with greater force against some kinds of marine shells. In these and other respects I can perceive little or no difference in value between the evidence of vegetable and animal remains if only equal caution is used in both cases in their classification. Now those of our plants whose congeners have been described before, though not examined in the most favourable circumstances for accuracy, will be found, I believe, upon the whole, to be correctly named. The doubt does not occur here, but at a more advanced stage of the inquiry. It is not that our specimens assigned to the genera *Glossopteris* and *Taniopteris*, *Vertebraria* and *Phyllotheca*, may turn out not to belong to those genera; but, admitting that there has been no mistake in the identification, it is still held to be problematical what conclusion is to be drawn from the occurrence of such kinds of plants in the rocks of Central India. To these questions I have, in the preceding papers, attempted a reply. *I may be permitted to add a few remarks on the evidence from our ancient Fauna.*

To render this testimony available, it is necessary to point out the relation between the argillaceous sandstone of Kámpti with its carbonaceous equivalent at the Mahádewas, which have afforded chiefly plants, and the fissile strata of Mángali with the bituminous shales of Kotá, which have furnished principally animal organisms. Now the succession of upper thick-bedded and under thin-bedded strata is the same at all these places, and favours the presumption that the rocks at all are identical. Then, the existence of bituminous beds at Kotá, the site of ichthyolites, as well as at the Mahádewas and other localities for our vegetable remains, increases the evidence for the identity of the strata at those places and also at Mángali, where, though there is no trace of coal, the character of the fish-scales suggests the connection with Kotá. That the ferns, which are so common in the argillaceous sandstone of Silewádá, have not yet been found at Mángali is no great difficulty when it is borne in mind how limited have been the investigations in the latter strata, and when it is remembered that, while most of the quarries even in the former abound in ferns, one is entirely destitute of them, *though it is remarkable for the variety of its fossil stems.* And although the Mángali fossil beds cannot, as regards fossils, be directly compared with the fern-bearing ones in the vicinity of Nágpur, yet, as has been suggested at p. 377, they may be mediately compared through the carboniferous formation of Virginia, which contains in itself, in the closest combination, the fossils of both these localities, proving that in America at least they existed together. It is to be wished that the nature of the terrestrial vegetation which has left its impressions on the *Lepidotus* slabs of Kotá were more particularly defined, for then we might discover in it some common term for estimating the contemporaneousness of the rocks with those in this province. As it is, however, I think an object for comparison may be conjectured. A few feet under the ichthyolite strata at Kotá there lies laminated sandstone, from which Dr. Bell procured leaves which

he was disposed to consider dicotyledonous. Now, as hitherto no true leaves of exogenous plants have been described from strata so low as the Lias or Oölite, it may be allowed me to suggest that the vegetable impressions in question, presenting, as they must have done, a well-defined and entire outline, and at the same time a distinct reticulate venation, were probably not leaves, but the anastomosing and simple fronds of some species of *Glossopteris*. Taking the whole of these circumstances into account, I conceive myself warranted in concluding that the strata immediately underlying the thick-bedded, sandstone in the three places referred to have all been deposited at the same period.

And now we are in a position to make use of the evidence from animal remains. In the Kotá fissile strata all the ichthyolites which have been found have homocercal tails, and on the authority of Sir P. Egerton belong to Liassic or Oölitic genera. Again, in the Mángali argillaceous sandstone not only do our *Estheriæ* resemble those of the Virginian Oölite, and our scattered fish-scales exuviæ such as occur in Jurassic strata, but even the *Brachyops*, which at first sight is apt to puzzle, is, as I have endeavoured to show, a Mesozoic form of Labyrinthodont. As it is in the Keuper of Wurtemberg that we meet with the most nearly allied genus, it is surely easier to refer our Mángali reptile to the Lias, which in Europe immediately overlies the Keuper, than to carry it into the more distant Permian over the line separating Mesozoïc from Palæozoïc organisms. The red shale at Korhádi, by its position under the plant-beds, when compared with the clayey strata found in similar circumstances at Kotá, affords additional proof, if any were wanting, of the identity of the superior fissile beds at both places. But by its animal remains it also strengthens the evidence which I have given above of the Jurassic age of the whole series. Tracks of Annelids seem to be rare in ancient formations. Many of the so-called specimens are now reckoned Cololites of fishes. The marks of well-ascertained genera, of the shape and habits of the earthworm, apparently occur first in the Lower Jura rocks, and as the traces on the Korhádi shale most nearly resemble those of that familiar Annelid, we may legitimately infer that the formation in which they are met with is Jurassic.

Combining the different parts of this evidence from animal remains, we perceive that the Lias or Oölite is the age for our laminated sandstones and bituminous or carbonaceous shales, which is pointed out by all with the exception of *Brachyops*, which, however, is altogether in favour of a Mesozoïc epoch. No countenance whatever can I find in our ancient Fauna to the view that any of the strata in question are contemporaneous with the Permian or carboniferous system.

Here we might conclude had we not to encounter a difficulty from Australia. In that land of natural paradoxes it appears from the statements of the most competent witnesses that plants which occur in Indian rocks with animals of Mesozoic forms have been imbedded with animals of Palæozoïc affinities. Whether, then, as it has been forcibly put to me by Professor Oldham, are we to hold that certain Palæozoïc organisms survived to Mesozoïc times in Australia, or that certain Mesozoïc organisms began there and here as early as Palæozoïc times? After the best consideration that I have been able to give this question, I have been led to accept the former alternative. It is not, however, on account of the fact that the fossils discovered in such ambiguous circumstances belong exclusively to the vegetable kingdom; for I believe that their evidence is not to be disregarded, any more than that of animals. No, it is because I have endeavoured to allow full effect to their testimony, and to appreciate the value of their conflicting teachings, that I have arrived at the conclusion that, even without taking our animal remains into account at all, but on the authority of our old-world plants alone, the rocks under discussion ought to be looked on as Jurassic.

For what are the plants which from their being discovered in the Australian coal-field have come to be viewed of such doubtful age when found in our Indian strata? They are (I quote from memory), *Sphenopteris*, *Pecopteris*, *Glossopteris*, *Vertebraria*, and *Phyllotheca*. Of these the first two number species in the Oölite of Europe most nearly resembling those in the beds of Australia. And the last, though hitherto not recognised as Phyllotheca

occurs, I have little doubt, in the Jurassic coal of Virginia as well as in the carbonaceous strata of New South Wales. Those three genera, then, are to be disposed of by simply letting their testimony in the West neutralise their evidence at the Antipodes. Only two genera, if I am not mistaken, now remain, viz., *Glossopteris* and *Vertebraria*, which have not been discovered in Europe or America, but are peculiar to India and Australia. These, as met with in this country, in the absence of proof to the contrary, we shall, on the ground of their association in New South Wales, in the mean time presume to be in favour of the Palæozoic age of their imbedding strata. But, to set over against them, we have a preponderance of acknowledge, and characteristic Jurassic genera, found not in a basin whose relations have yet to be ascertained, like that of Newcastle and Hawkesbury, in the southern hemisphere, but in the Oölite of England, having the Palæozoic rocks beneath, and forming part of the most complete geological series in the world. There is first the *Taeniopteris* of Kámpti, Rájmahál, and the Dainda, in which we see the connection with the slate of Stonefield, as we do again in the *seed-vessels* of this province; then there is the disc-bearing *asterophyllites*, or whatever it may be called, of Silowádá, which is scarcely distinguishable, from that at Scarborough; and lastly there are the *Cycadaceæ* of the two Bengal sites, which suggest the relation with the two English localities. When all this amount of evidence is compared with that of the two genera specified above, I think it will be admitted that even confining our view to vegetable remains, the probability is greatly on the side of a Jurassic age.

But when to this we add the testimony of the animal remains, which, as I have shown before, is all in favour of a Mesozoic epoch, it appears to me that little doubt will remain of the correctness of the view which in 1853 I advocated regarding the age of our argillaceous sandstone and its equivalent the Indian coal.

I may only add that, if we are bound to sum up for the Jurassic age of those strata, it is easy to perceive how even one of the two genera of plants that were presumed to bear evidence on the other side, though, I believe, unknown in the Mesozoic formation of the West, does nevertheless when ranged with all the other simple frouded ferns which we discover in our Indian rocks, and which out of India numerically culminate in the Oölite, admirably harmonise with this conclusion. And deducting *Glossopteris*, with its many species, from the Palæozoic side of the question, and adding it to the other, there will be left the single *Vertebraria*, with its solitary species, of which we can give no explanation on the hypothesis that the rocks which we have been considering belong to the Lias or lower Oölites.—S. H.

Nagpur, August, 1856.

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